TECHNICAL REPORT
73-59-CE

THE CHANGING CAPABILITY OF THE TEXTILE INDUSTRY TO SUPPORT NATIONAL DEFENSE

DECEMBER 1975

Approved for public release;
distribution unlimited.

UNITED STATES ARMY
NATICK RESEARCH and DEVELOPMENT COMMAND
NATICK, MASSACHUSETTS 01760

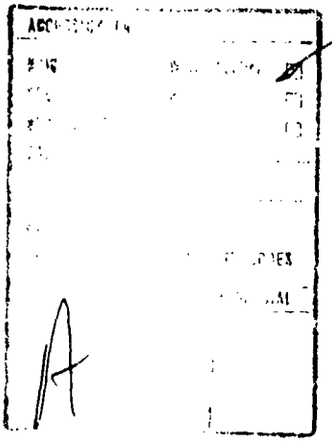
Request that all copies of AD 777791 (The Changing Capability of the Textile Industry to Support National Defense), dated April 73, be replaced IMMEDIATELY with copies of enclosed version, dated December 75. The latest version is considered to be a technical update of earlier report.

THE CHANGING CAPABILITY OF THE TEXTILE INDUSTRY

TO SUPPORT NATIONAL DEFENSE

U. S. Army Natick Research and Development Command

December 1975



FOREWORD

The inclosed report was prepared by Dr. S. J. Kennedy who, for many years was the Director of the Army's clothing and textile research at Natick Research and Development Command.* The report, which was prepared at the request of the US Army Materiel Command (AMC) was originally published in draft form in 1973. It is a significant report in that it:

- clearly foresaw the petrochemical shortage;
- provides an excellent review of the problems facing the Defense Department today in the clothing and textile area in the event of mobilization;
- is an historical and well-documented effort that should be of value to decision-makers within the Defense Department and the industry insofar as it relates to military mobilization problems in this area.

The petrochemical shortage noted arrived far sooner than anticipated in the report, but has not, to date, created any significant shortages of man-made fibers in the textile market. However, the experience has underlined the need for the Army to be sensitive to any potential areas of shortage in textile materials, and direct its research efforts accordingly.

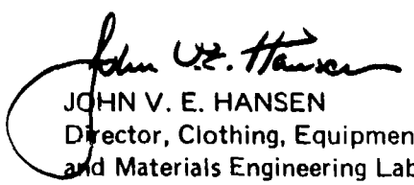
Because of the potential impact of this report, the Army Materiel Command Steering Committee was formed to develop solutions to the problems identified. This AMC Committee, established in 1973, consists of representatives of the Army, DSA/DPSC, and other persons experienced in the Army's clothing and textile area. As one of the first steps, the AMC Committee submitted the report for comment to leading authorities apt to be affected by the report. Congressman Sisk (Dem., Calif.), among others, recognized the problems cited, and under his sponsorship, an ad-hoc Cotton and Textile Defense Capability Committee (CTDCC) was formed to analyze and comment on the report insofar as it affected wool- and cotton-containing materials. This Committee's effort, which was concluded under the direction of Congressman Bowen (Dem., Miss.) in 1974-75, issued its comments and analysis of the report; these findings, together with the membership of the CTDCC, are given in Appendix C.

As a result of these recommendations, Congressman Bowen commended the US Army Materiel Command for its foresight in initiating this report. In addition, Congressman Bowen's office has already implemented one of the recommendations by requesting the General Accounting Office to study our current practices and policies regarding stockpiling insofar as they relate to the problems identified in the report.

* then the US Army Natick Laboratories.

It should be noted that the Cotton and Textile Defense Capability Committee confined its study to tne areas of cotton and wool-containing materials. Separately, an Army Materiel Command Steering Committee was formed to deal with the remaining problem areas in the report, which include areas such as parachute nylon and all-synthetic webbings. This effort is nearing completion and will result in specific recommendations to the Army Materiel Command for actions to be taken in this area. In addition, the Natick Research and Development Command has initiated a number of research efforts in areas such as seeking substitute non-woven materials to replace heavy duck required for tentage and similar applications.

The many comments received on the report indicate that it performs a valuable service in describing the many changes that have occurred in our economy, in industry, and in Defense Department requirements, all of which will affect future mobilization efforts in clothing and textile items. As noted in Appendix C, the recommendations of the Cotton and Textile Defense Capability Committee, which were prepared by the Army's and the Department of Agriculture's research organizations, include a significant expansion and acceleration of clothing and textile research efforts. On November 12, 1975, Congressman Bowen endorsed and forwarded to the Secretary of Defense the Committee's recommendations for an expanded and accelerated research and development effort in clothing and textiles. The need for this has also been recognized by the Defense Supply Agency, and the program recommended, if implemented, would not only provide answers to some of the potential mobilization problems, but would also provide a stimulus to the clothing and textile industry. The Clothing, Equipment and Materials Engineering Laboratory of the Army's Natick Research and Development Command is continuing to address the problems cited and is also continuing to assess the impact of recent industry developments (including OSHA and EPA regulations) on the Defense Department's mobilization requirements in the clothing and textile area.



JOHN V. E. HANSEN
Director, Clothing, Equipment
and Materials Engineering Laboratory
(Chairman, AMC Steering Committee)

AMC Steering Committee

John V. E. Hansen, Chairman
Joseph Lindwarm, Hq., AMC
John E. Murdock, Jr., Hq., AMC, Chief, Individual Soldier Division
Frank J. Rizzo, Retired AMC expert
Charles N. Gardner, Retired AMC expert
Martin H. West, Retired DSA expert
Dame S. Hamby, Head, Department of Textile Technology
North Carolina State University
Stanley Backer, Head, Fibers & Polymers Laboratory
Department of Mechanical Engineering
Massachusetts Institute of Technology

OUTLINE

APPENDICES

I. INTRODUCTION

During the past ten to fifteen years profound changes have been taking place in the United States textile industry and in the American textile market which are of great importance to the Department of Defense in respect to the future capability of the industry to meet military needs for textiles in large quantities quickly in a time of mobilization. These changes have included:

— Very large imports of textiles, which have retarded expansion of textile industry production capacity proportionate to the growth of the market, particularly in the broad woven goods segment of the industry upon which the military is dependent for by far the largest part of its military textile requirements.

— An increase in the rate of change in consumer textile products which has caused continual changes in the make-up and production capabilities of the industry's production base.

— Long-term trends in the prices of the various textile fibers as a result of which cotton is no longer consistently the lowest-price textile fiber.

— Growth in the consumption of man-made fibers to the point where the consumption of these fibers exceeds that of the natural fibers.

— A technological revolution in practically all phases of textile manufacturing.

— The rise of labor shortages in the major textile manufacturing areas.

The above trends, along with others that could be cited, have already had a definite effect upon the potential of the textile industry to produce the textiles required by the military for support of military operations. A continuation of these trends into the 1980's, which appears likely, may make it very difficult or even impossible for the textile industry to supply the textiles needed for support of a major military mobilization.

Industrial mobilization planning as it has been carried on in the past by the Department of Defense has assumed the production base of industry to be relatively static; i.e., that a mill having certain equipment and making a certain type of product would continue to be making essentially that same type of product at some future date. Industrial mobilization studies of the textile industry prior to World War II could be based upon such an assumption because the industry in general conformed to that pattern.

Today, however, the industry is subject to such rapid change that it would be not only futile but misleading to attempt to base plans for mobilization of this industry at some future time upon this assumption. In order to keep abreast of changes in the market, textile management has become basically market-oriented and is prepared to change manufacturing facilities to meet market trends far more readily than ever in the past. Mills making one product this year may be converted a year or two from now to making a wholly different product using quite different production equipment.

In contrast to these industry trends, the technical requirements for military textiles are relatively inflexible. There are certain functional requirements in the clothing and equipment of the soldier, in body armor, in parachutes, and in other military textile uses which can only be met by specific types of textiles. Some changes in the textiles used by the military services can be expected to occur as a result of technological advances, particularly in the development of new fibers and modifications in existing fibers and manufacturing processes. Also, military research and development directed toward exploitation of technological advances in industry will undoubtedly lead to changes in military textiles. Yet, there are certain basic technical requirements that must be met, and for these an adequate industry base to produce these kinds of textiles would be needed.

That a critical supply problem could occur in textiles has not been seriously considered in the past by the military services. Generally,it has been assumed that, in an area like textiles, where the military product resembles the kinds of products the industry makes for civilians in time of peace, the industrial capacity could be quickly turned around in time of war to producing what the military would need.

The performance of the textile industry in meeting military requirements in World War II, the Korean War and our involvement in Southeast Asia has contributed to this attitude. However, the unusual circumstances and the extraordinary efforts which made it possible for the textile industry to supply the military with its requirements during World War II are no longer generally known. Also, just how the supply goals were met during the Korean War and why the problems that arose did not create a crisis are likewise not remembered. The creeping rate of involvement in Vietnam would not have been expected to create a serious crisis in obtaining supplies of textiles. Yet, at one point in the war, consideration had to be given to the possible purchase of cotton duck abroad, in addition to which support of the Army, Republic of Vietnam (ARVN) was met by large off-shore procurements of many kinds of textiles.

There is a complacent feeling with respect to textiles that "it could not happen here" — that the textile industry will always be able to take care of military needs.

That can no longer be taken for granted.

The textile industry as it existed in these three war periods of the past thirty years no longer exists. The circumstances which made possible the successful supply support of textiles and products made from them during these three wars could not possibly be re-created. Both the military services and the textile industry have a whole new set of factors to deal with, and over the next ten to fifteen years, far greater changes must be expected to take place. To be prepared to keep pace with the changing production capabilities of the textile industry, a major re-orientation is required in the attitude of the military services toward the industry, in the development and adoption of new materiel using textiles, and in industrial mobilization planning.

II. MILITARY REQUIREMENTS

The term "military requirements" is used to refer both to the quantities of supplies that may be needed by the military, and also to the functional performance characteristics of materials and items of supply. Quantitative requirements in turn must be defined both in terms of the rate at which supplies must be made available and the total quantities needed.

Quantitative Requirements

Perhaps the most effective way by which to gain a perspective as to the amount of supplies such as textiles that would be required in a major mobilization would be to review the nature of the mobilization that has occurred in each of the three wars in which our country has been engaged during the past thirty years.

Figure 1 shows the rate of increase in total military strength for each of the three wars: World War II, Korea and Vietnam. The base date used for World War II is June 1941, at which time mobilization was actually going forward rapidly, as is shown in Table I: from June 1939 to June 1941, the strength of the military forces had been increased from 334,473 to 1,801,101. (The further increase by the end of December was relatively small.) June 1950 has been used as the base date for Korea, and June 1965 for Vietnam.

It will be evident from considering both the rate and the extent of mobilization in each war that they represent three entirely different types of mobilization. They can perhaps be best categorized as total mobilization of the country's resources for an all-out war for World War II; a limited but rapid mobilization necessitated by an enemy attack in a single theater for Korea; and a gradual mobilization to support a limited military objective for Vietnam.

With respect to mobilization of industry to support the military forces in these three engagements, it will be evident that the demands placed upon the industry were completely different in each case. In World War II, total strength of the military forces was increased to over six times that of the base period, whereas for Korea, it never rose to more than two and a half times the pre-war figure. The comparison between total manpower in the three war periods is clearly shown in Figure 2 which shows the actual strength of the armed forces over this period.

Looked at from the standpoint of rate of mobilization, the military strength was almost doubled in the first seven months of the war in World War II and then more than doubled again during the next year, whereas in Korea, it was doubled during the first year of the war, and did not rise much further during the balance of the war. In Vietnam, military strength

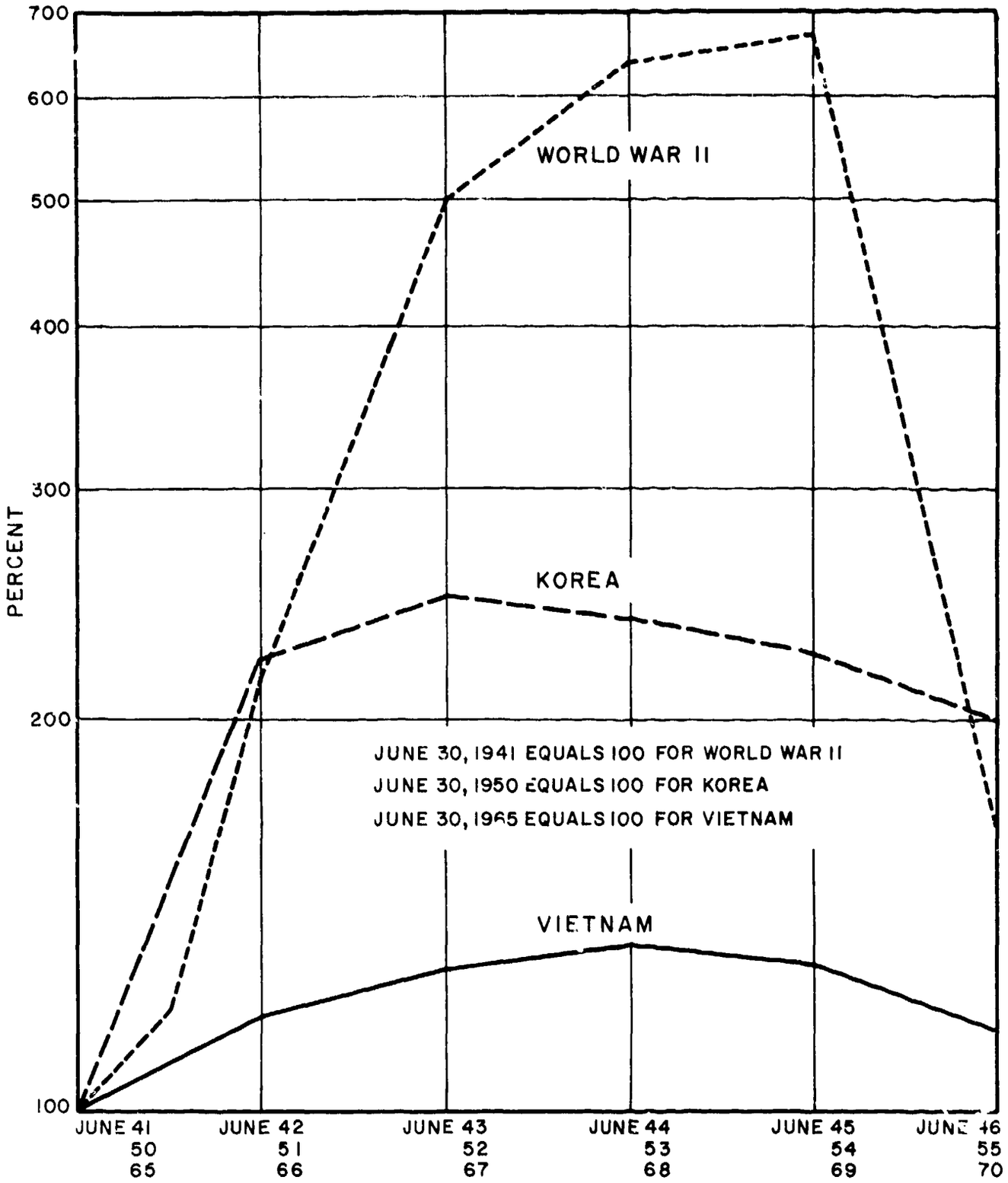


FIGURE 1 RATE OF INCREASE OF TOTAL MILITARY STRENGTH WORLD WAR II, KOREA, VIETNAM

TABLE I

Total Military Personnel

World War II, Korea, Vietnam

World War II			Korean War			Vietnam War		
Year	Strength	Index	Year	Strength	Index	Year	Strength	Index
30 June 1939	334,473	—	—	—	—	30 June 1963	2,699,617	—
30 June 1940	458,365	—	—	—	—	30 June 1964	2,687,409	—
30 June 1941	1,801,101	100	30 June 1950	1,460,261	100	30 June 1965	2,655,389	100
31 Dec 1941	2,149,157	119	30 June 1951	3,249,455	223	30 June 1966	3,094,058	117
30 June 1942	3,858,791	214	30 June 1952	3,635,912	249	30 June 1967	3,376,880	127
30 June 1943	9,044,745	502	30 June 1953	3,512,949	240	30 June 1968	3,547,902	134
30 June 1944	11,451,719	636	30 June 1954	3,302,104	226	30 June 1969	3,460,162	130
30 June 1945	12,123,455	673	30 June 1955	2,935,107	201	30 June 1970	3,066,294	115
30 June 1946	3,070,088	170						

Source: Selected Manpower Statistics, Department of Defense, CASD Comptroller, Directorate for Information Operations, April 15, 1972.

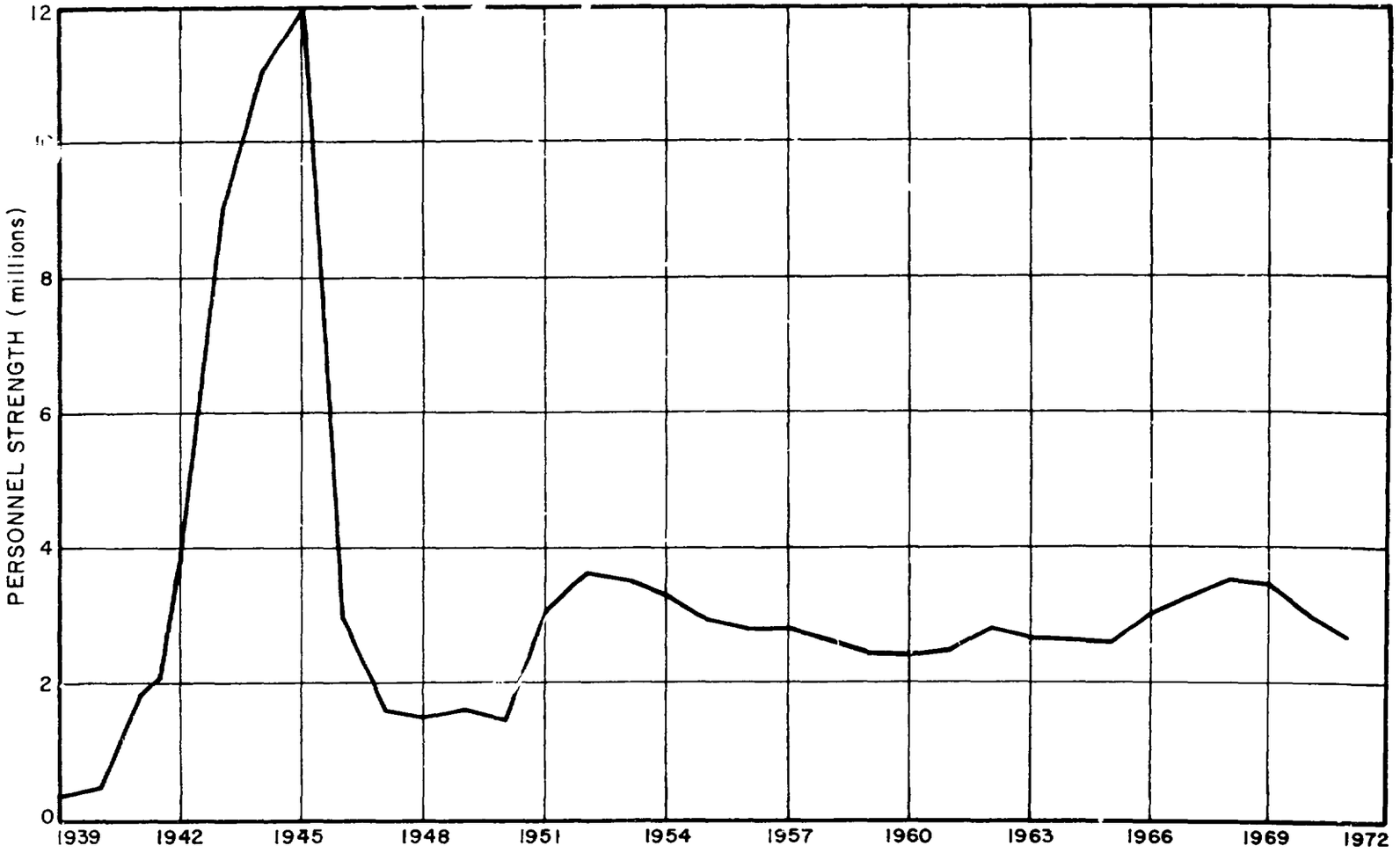


FIGURE 2 ACTIVE DUTY MILITARY PERSONNEL

rose only gradually to a peak three years after the major military effort got underway.

From what is indicated in these charts, reflecting on our experience in mobilization in three wars during the past third of a century, it is clear that there is no single pattern or formula from which to project possible future requirements, or the character of the industrial mobilization that might be thrust upon the textile industry at some future date.

The most that can probably be said at this point might be that the importance of maintaining strong forces in being to prevent or deal promptly with brush fires before they grow into major confrontations, has apparently come to be recognized as an essential element of our military posture. Even this position, however, might be subject to modification with some easing of international tensions.

How then does one project possible needs from which some estimate might be arrived at that would be meaningful in relation to the industry's future capacity for production?

Industrial mobilization planning has had to deal with this problem since it was first brought into being under the National Defense Act of 1920, which assigned to the Assistant Secretary of War responsibility to assure "adequate provision for the mobilization of material and industrial organization essential to war-time needs."

The experience in World War I where we recruited two million men and sent them overseas after an average training period of nine months, but found it would take two years to supply them with munitions, necessitating their use of equipment furnished by our Allies, demonstrated that manpower and industrial mobilization had to be simultaneous and synchronized in military preparation.[1]

The general principles followed in industrial mobilization planning have been to locate sources that might be able to produce standard items of equipment, to allocate to each a certain quantity of the overall estimated requirement for a particular type of material, and to prepare plans which would enable that firm to go into production quickly, with minimum loss of time, when an emergency arose.

The details of this type of planning are well known to the industry and need not be repeated here. Particularly critical are the measures that could be taken to reduce the time by which the supplies could be produced. These involve both the administrative lead-time of the government procurement activity, and any constraints which might be placed upon it with respect to procurement action, and the production lead-time which, even when compressed to a minimum, cannot physically be reduced beyond a certain period of time before goods can come off the production equipment.

---

[1] Thomas M. Pitkin and Herbert R. Rifkind, Procurement Planning in the Quartermaster Corps, Quartermaster Corps Historical Studies No. 1, March 1943. Foreword.

Here, it may be pointed out that during World War II, in an all-out committment, many contracts were negotiated and a contractor could come into the procurement office and walk out with an order, and almost without regard to cost, stop his factory and start up on the military product. In contrast, during the war in Vietnam, normal procurement restraints prevailed for the most part, so that administrative lead-time amounted to about three months before the contract could be awarded.

What the production lead-time would be in most textile mills would vary with the product, but for practical purposes, a period of not less than three months would be required to start getting gray goods made from spun yarns off the looms, with another month for finishing, and with the rate of delivery depending upon the number of looms committed to the contract. The textile industry normally operates on contracts to run for not less than ten weeks. Added together, this would give a time period for delivery of a contract of about six months. One goal of mobilization planning has been to find ways to reduce this overall time periodbefore anemergency developed.

This matter of rate of mobilization, both of men and materiel, is highly critical from the standpoint of meeting a military emergency.

In both World Wars I and II, we had warning time for preparation, with other powers engaging the enemy while we had time to bring to bear the long-run superiority of American potentiality for war, rather than having had to be in a state of readiness for war which might have determined if we would have the ability to use that potentiality.

A significant comment with respect to this whole matter of preparedness was made by General Eisenhower in his final report as Chief of Staff of the Army, in which he said, "What we are able or not able to do within the first sixty days of another war will be decisive in its determination of our ability to carry the war to a successful conclusion." [2]

While this statement would not have been applicable to our creeping involvement in Vietnam, it proved literally true in Korea. From June 25, 1950, when the North Korean invasion of South Korea began, it was only by September 10, after a strategic retreat, that the United States and the allied United Nations forces could stabilize the front at the beachhead around Pusan, thereby occupying the enemy forces so as to permit the Inchon landing on September 25.

It is no criticism of the procurement plans prepared prior to World War II that mobilization for that conflict actually began during peace-time, two years before Pearl Harbor.

---

[2]Dwight D. Eisenhower, Final Report of the Chief of Staff, United States Army, to the Secretary of the Army, February 7, 1948. pg. 17.

This partial mobilization, to which was added the purchase of supplies for Lend-Lease, brought military procurement of all types of supplies to a relatively high level before December 1941, transcending the procurement plans that had been developed, although the groundwork that had been laid with the industry in the preparation of the plans proved very useful in getting industry ready for production for military support.

World War II confirmed the belief that it was the ultimate capacity of industry to produce that would determine the outcome of a war. The term, "Arsenal for Democracy", which was a key slogan during World War II, expressed this concept.

Similarly, our experience in Korea, which did not involve full mobilization with attendant demands on the nation's industrial strength, confirmed, however, the importance of a strong industrial base to support a relatively large military establishment in a cold war setting. In this conflict, the concept of readiness for total mobilization, in the event it became necessary, received strong recognition.

In planning in respect to some future emergency it must be kept in mind that the estimates of the quantities of textiles that would be needed would be the end result of predictions and calculations based upon assumptions and objectives established at high policy levels. Such predictions would have to involve the consideration of a highly complex array of unknown future events, most of which would be beyond the control of those formulating the plans. Included would be assumptions as to basic strategic plans, enemy capabilities and probable intentions, possible theaters of operation, anticipated size and composition of the military forces required, the projected rate of mobilization, methods of delivery of troops and supplies, and, quite obviously, a host of other factors. As changes in our defense posture and international tensions occur, changes in estimates of the strength of the forces needed would undoubtedly also be altered; such alterations, in turn, would necessitate reconsideration of the industrial mobilization plans.

While all mobilization plans are affected when such changes occur, those pertaining to support of the individual soldier are particularly vulnerable, both in respect to the total quantities of supplies required and the particular types needed. The climate of the projected theater of operations, for example, would determine whether cold weather or hot weather clothing was needed, and what kinds of sleeping gear, shelter and other troop support equipment would be required. The threat of the possible use of chemical warfare by an opponent could necessitate making available large supplies of chemical warfare protective clothing. There would also be the possibility that new types of weaponry or new chemical warfare agents might be employed which would exceed the protection capabilities of available personnel armor or protective clothing, necessitating immediate redesign of existing items, or the production of new ones, with a corresponding shift of textile production and the end items made from them, to meet such new threats.

In determining requirements for textiles and clothing, there are further production and distribution factors related to sized items. These necessitate the production of added quantities to assure fit at the point of issue. Also, there is the uncertainty as to replacement requirements, since some items of clothing and equipment have relatively long potential life, and their rate of replacement would depend upon the intensity of the conflict and the practicability of field repair and re-issue.

Just what build-up in military manpower might be necessary in a future mobilization is beyond any determining at this time. However, it may be helpful, in thinking about this problem, to use a hypothetical situation in which mobilization would involve at least doubling the size of the armed forces from a base of around two million men for conducting a war in a temperate climate area. Such a hypothesis falls in-between the two extremes of the World War II situation, and the slow build-up in Vietnam, and can form the basis for checking the impact of trends in the textile industry upon its capacity for military production. Also, it may serve as a useful base-line for projecting upward or downward the possible requirements of the military.

Technical Requirements

The textiles required for military use can be grouped into nine general classes as follows:

TABLE II

PRINCIPAL CLASSES OF MILITARY USES FOR TEXTILES

Specific Military Technical Requirements

Uniforms

- Winter Service Uniform
- Summer Service and;or Semi-Dress Uniform
- Utility Uniform

Protective Clothing/Equipment Systems

- Hot Weather Clothing
- Cold Weather Clothing (Including Temperate Climate Winter Clothing)
- Extreme Cold Weather Clothing
- Desert Clothing
- Army Aviators' Clothing
- Combat Vehicle Crewmen's Clothing
- Chemical Warfare Protective Clothing
- Personal Equipment
- Personnel Armor

Tents, Paulins and Covers

Parachutes and Related Airdrop Equipment

- Personnel Parachutes
- Cargo Parachutes
- Cargo Tie-Down Equipment

Miscellaneous Military Uses, not included above

Technical Requirements Similar to Those of Commercial Materials

Other Clothing

- Hospital, Service, Safety, etc.

Housekeeping Textiles

- Sheets, Towels, Blankets, etc.

Textiles Used as Components of Other Military Materiel

- Tire Cords
- Hose and Belting
- Electrical Applications
- Reinforcements for Plastics
- Other Component Uses

Textiles Used in Industry in the Production of Military Materiel

It will be apparent from the above list that the textiles required for support of military uses fall into two general groups: the first five classes, which have distinct military technical requirements related to their military uses, and the lower four classes for which the technical requirements would not be significantly different from those for products used for similar purposes in the civilian economy.

With respect to the latter, it need only be said that in a mobilization situation there would not need to be any significant changes in industrial production. The principal impact would be a surge upward in the quantity of those types of textiles demanded of the industry, with the increase proportional in some way to the rate of mobilization or the general rate of production of military hardware.

It is the textiles in the first five groups which are normally thought of as "military textiles". This is proper since they have distinct functional requirements, which although matched in some measure in corresponding items used by civilians, would require both in their firm technical characteristics, and in the volume in which they would be required in a mobilization, large scale changes, in time of war, from normal commercial production.

It is important, accordingly, that there be a clear understanding as to the required technical characteristics of these military textiles. These are listed in Appendix A according to "critical", "essential" and "desirable." The definitions used for these requirements are as follows:

Critical — Requirements which cannot be compromised without endangering life, health, or military capability.

Essential — Requirements essential to end item or system performance, the absence of which would adversely affect the accomplishment of a military mission.

Desirable — Requirements which enhance the protection of the user, extend the life of the item, or build morale through improving the military appearance of the troops.

The technical characteristics listed in Appendix A can be accepted as based on extensive research and testing which have established functional performance levels for the materials to be used in the protective clothing and equipment or other items of military equipment. They establish limits beyond which the substitution of commercial materials, either "off the shelf" or from commercial production, could not be made without compromising critical or essential requirements or impacting on the functional efficiency of combat troops in military operations.

The materials currently being used for these various uses, however, are not to be regarded as necessarily the materials which would be required at some future date. Therein lies one of the problems of establishing military reserves. Technological progress of the type which has been occurring in the textile industry during the past twenty years should make it possible to produce new and more efficient materials every ten years or less. This could apply at present both to the textile fibers themselves and to the form in which they are used in the various end items.

On the other hand, it will be apparent from examination of the critical and essential requirements of most military textiles, that these requirements can be met at this time only with woven textiles. There appear to be few places where any significant quantities of knit or non-woven fabrics of the types presently available could replace broad woven fabrics. For many uses, only broad woven textiles approaching the limits of weavability will meet the technical requirements.

There are also significantly large requirements for narrow woven fabrics — webbings and tapes. While the requirement for heavy webbings has been reduced by the adoption of lighter weight nylon webbings in the soldier's pack and load carrying system, the total requirement must be recognized to be large. In this connection it should be noted that there had to be priority action in World War II to build webbing looms to supply the military need.

Other important military technical requirements include those in dyes, particularly dyes in camouflage colors; and specialty textile chemicals; and production equipment for making such items as helmets, parachutes, and tents. In peace-time, there is only a limited industry capacity for these items.

Administrative Actions to Reduce Requirements

The support required of the textile industry in any future mobilization will be different in many respects from what was required in both World War II and the Korean War, and also in important respects from what the industry has been asked to do during the war in Vietnam.

The centralization of procurement of textiles, clothing and related equipment in the Defense Supply Agency, specifically at the Defense Personnel Support Center, has overcome what was one of the most frustrating problems of World War II where there were three separate procurement centers for the Army, the Navy, and the Marine Corps, each competing with the other for the same production facilities and each armed with priorities.

While a modus vivendi was established between these competing services before the war was over, there can be no question that the concentration of all procurement for all the military services in a single procurement center is a distinct gain for the industry and would make its support more effective.

Also, over the past fifteen or more years a major program has been conducted to eliminate as many separate items from the system as possible and to concentrate on standard items which can be used by all of the military services. This standardization and simplification program, which was initiated by a Department of Defense Directive issued 15 October 1954 and carried out over the next ten years, extended throughout the entire spectrum of clothing and equipment items and their component materials. It resulted in substantial savings in costs of procuring and issuing the multiplicity of textile items which are required for support of the military forces. More important, from the industry standpoint, military requirements became concentrated on fewer items.

A summary statement which was prepared in 1962, while the program was still in progress, showed that 88,658 line items had been eliminated from the supply system. (On sized items, each size is carried as a separate line item of supply.)

Examples of standardization would include the adoption of single items for common uses such as underwear, socks, utility clothing and equipment. The case of dress shoes illustrates what was accomplished. During World War II, the Army, Navy, and Marine Corps all bought different shoes made over different lasts. A total of around 295 sizes was required to cover each using service. By the adoption of a new last, common to all services, agreement on the use of black color shoes, and the elimination of alternate widths, a total of only 113 sizes met all requirements except for the Marine Corps which continued to use a brown shoe, although made over the same new last.

This same type of standardization and simplification has been extended throughout the textile and clothing area including component materials in service uniforms. It has resulted in reduced costs to industry and to the government through permitting large runs on a few standard materials and eliminating the costs and delays in changing over from one fabric to another. It has also enabled industry to plan more effectively when military textiles were to be procured and substantially simplified the whole procurement/production process.

In addition, by adoption of the point system for quality definition of textiles, the military and the industry jointly have achieved a single set of standards by which to determine quality levels for acdeptance. This action, together with a continuing program of coordination of specifications with industry has greatly improved communication between the military services and the textile industry, and the basing of the requirements for military textiles upon the changing capabilities of the industry and trends in commercial production.

Industrial Mobilization Planning

A brief word should be said also about industrial mobilization planning and the Mobilization Materiel Procurement Capability for textiles, clothing and other end items made from textiles. Current industrial mobilization planning takes into account the general principle that mobilization reserves of materiel plus stocks in the hands of troops and due in are expected to meet the demands expected to be placed upon the supply system subsequent to M-Day until the rate of industry production for an item of supply equals or exceeds the rate of consumption and continues to do so thereafter. This point in time, referred to as "P-Day", of necessity varies from one product to another.

The most optimistic estimates, where an all-out mobilization effort might be undertaken, could not place P-Day earlier than twelve months after M-Day on most textile products. This timing includes starting of deliveries of textile materials within 3-1/2 months after M-Day, and deliveries of end items starting about 3-1/2 months later. [2a.]

To raise the level of production to a rate that would meet possible demand for initial issue and pipeline supply could not realistically be expected to occur in less than twelve months, if it could be done by that time. Many factors would, of course, influence this timing, and it could be considerably longer on some items. It would be scarcely realistic to assume, however, that after a period of peace lasting for ten to fifteen years, mobilization reserves of cloth and end items could be large enough to spare the industry the need for a major immediate conversion to military textiles on a very large scale, particularly during the first year of the war. The extent and character of such a conversion, in response to industrial mobilization requirements, constitutes, in effect, the precise problem with which this study is concerned.

2a. U.S. Defense Personnel Support Center, Production and Leadtime Estimates, Philadelphia, Pa., July 1967.

III. INDUSTRY RESPONSE TO MOBILIZATION REQUIREMENTS

Conversion of industry on a mobilization scale to the production of military textiles and related products would need to include, among other actions, the following:

— An overall increase in production, if at all possible. This would require some unused capacity being available, relatively large supplies of raw materials, and extra manpower in the major textile producing areas.

— Conversion of mills from making civilian products. This would include utilizing the capacity both of mills making products akin to those required by the military, and those which normally would produce quite different textiles, but which could be converted if either raw materials or yarn could be made available, and if cost was not a deciding factor.

World War II

During the first year of World War II, when a major mobilization necessitated all-out production, the textile industry did succeed in increasing total production, as shown in Figure 3.

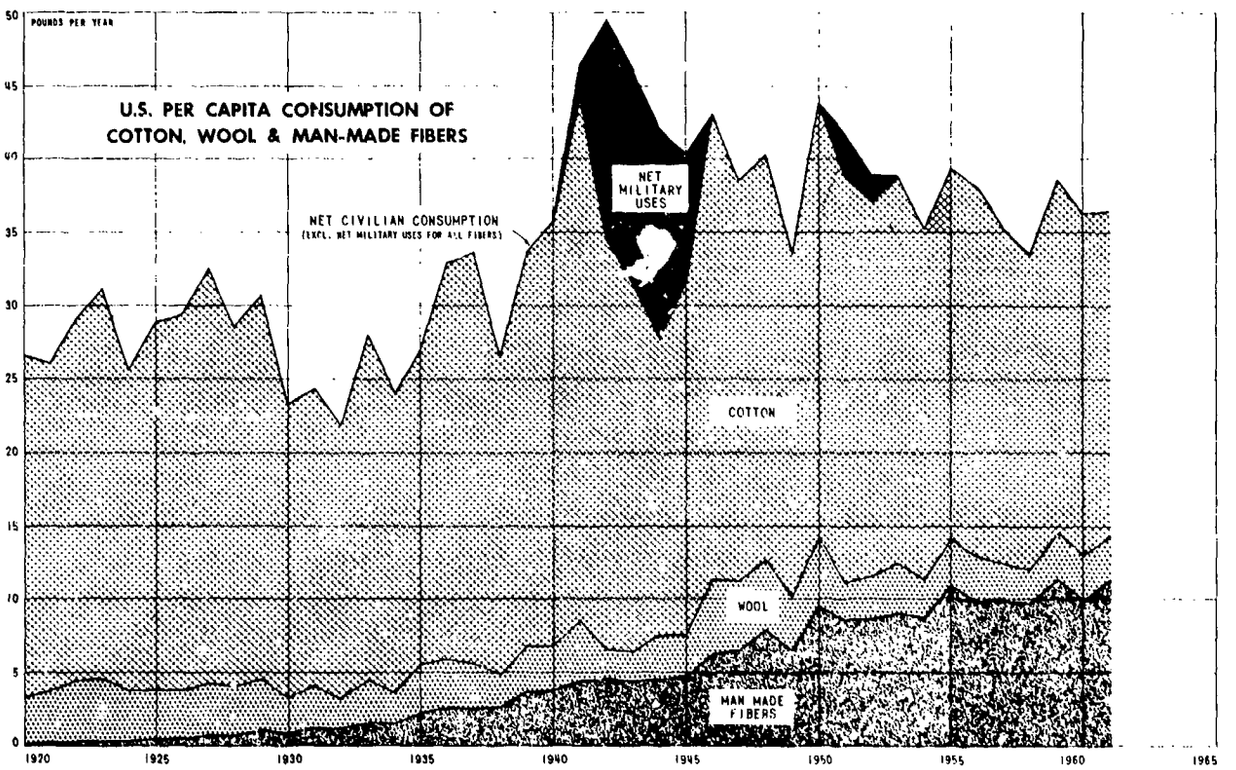


Figure 3
Source: Textile Economics Bureau, Inc., "Textile Organon", March 1962.

In terms of mill consumption of fibers, a peak of 6,896 million pounds was reached, an increase of 6.3% over the previous year, and a high that was not equalled again until 1962. This level of production could not be maintained, however, due primarily to the labor shortage that developed in the textile industry during the war.

Deliveries of textiles, purchased as such by the Army Quartermaster Corps, but not including deliveries to the Navy and Marine Corps, are shown in Table III.

TABLE III

DELIVERIES OF SELECTED TEXTILE FABRICS
TO THE QUARTERMASTER CORPS
(000 sq yds)

	Emergency Period July 1940—Dec 41	1942	1943	1944	Jan.—Aug. 1945
Cotton Cloth	157,441	535,017	626,256	529,514	268,250
Wool Cloth	70,025	120,978	86,220	56,592	70,479

Source: Statistical Yearbook of the Quartermaster Corps, 1943, 1944, 1945.

If allowance is made for the added requirements for the Navy and Marine Corps which were 25% of the Army strength in 1942, 29% in 1943, and 43% in 1944, and for the indirect requirements where the textiles were not procured as such directly from the industry, it will be evident that total military requirements were cutting sharply into those segments of the industry where military requirements were concentrated.

The reduction in the amount of textiles which was left for the commercial market, based upon total fiber consumption has been shown in Figure 3. From a per capita consumption for civilians of 44.2 pounds in 1941, the amount dropped to 34.3 pounds in 1942, and continued to decline to only 27.7 in 1944. This shortage of essential civilian goods in turn created problems of price control of tremendous difficulty which, in fact, proved beyond solution. Clothing price rises accounted for nearly half the rise in the total consumer price index during the war, and the shortage in essential civilian clothing was even more acute by the middle of 1946 than at any time during the war.[3]

Three facts stand out from this World War II industrial mobilization: to meet military demands for a troop mobilization of that size, a very large segment of the total industry had to be converted to producing military textiles. Unused capacity and the conversion of some mills which were curtailed from their normal civilian markets made only a limited contribution to the total output.

---

3 - Wilfred Carsel, "Wartime Apparel Price Control", Office of Price Administration, U.S. Government Printing Office, Washington, D.C. 1947. p. iii.

Second, the prompt conversion of sufficient production capacity to meet military demands was successfully achieved only because of the immediate availability of large supplies of raw materials.

Third, the industry did succeed in building up production of military textiles during the critical year of mobilization at a sufficient rate to keep ahead of manpower mobilization. Figure 4 and Table IV show that the peak in textile production, as shown in terms of mill fiber consumption, was reached in 1942, whereas a corresponding rise in manpower came in 1943. Textile production then levelled off while military strength continued to increase.

TABLE IV

TOTAL FIBER CONSUMPTION FOR MILITARY USE

Year	Total Fiber Consumption Calendar Year	Index	Military Personnel Strength as of 30 June	Index
	(000,000 lbs.)		(000,000)	
1941	390	100	1.8	100
1942	2179	560	3.9	214
1943	2291	588	9.0	502
1944	2304	590	11.5	636
1945	1646	423	12.1	673

Source: Textile EconomicsBureau, "Textile Organon", March 1962; "Selected Manpower Statistics", Department of Defense, OASD Comptroller, April 15, 1972.

Conversion of the Woolen and Worsted Industry

There were four types of military textiles which presented special production problems during World War II. These same types can be expected to present corresponding problems during any future mobilization, since they represent military uses having basic technical requirements. One of these areas was uniform fabrics.

In the conversion of the woolen and worsted industry to military production during World War II, the two basic requirements outlined above could fortunately be met: there was an ample supply of raw wool, and there was available unused manufacturing capacity.

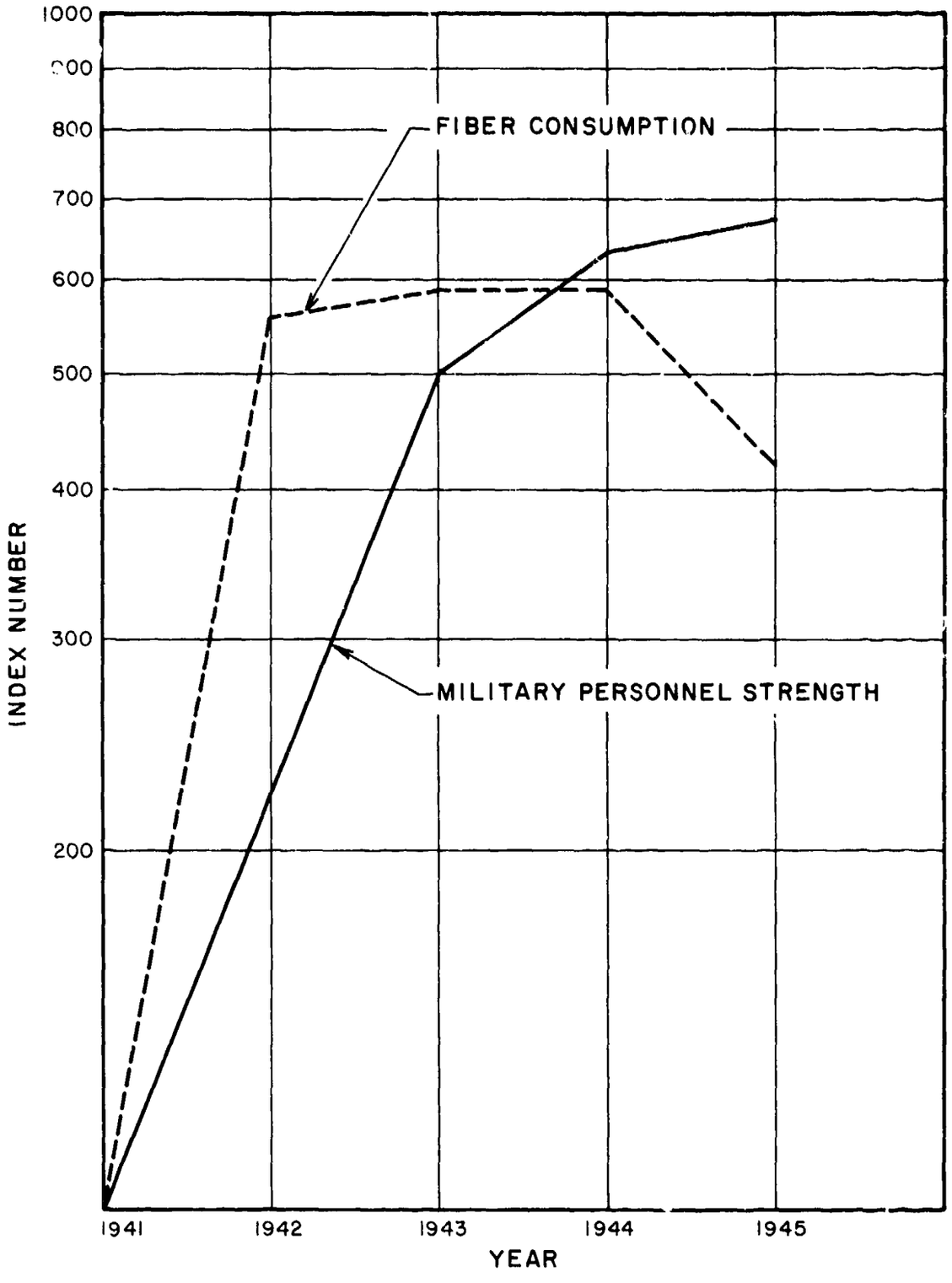


FIGURE 4 FIBER CONSUMPTION FOR MILITARY USES COMPARED WITH RATE OF MOBILIZATION (WORLD WAR II)

By agreement between the governments of the United Kingdom and the United States in December 1940, a stockpile of Australian wool was established in the United States. Due to the submarine blockade, which cut off Australia from European markets, it was decided to move Australian wool to the United States and to create a stockpile of 250 million pounds which could be used by either government. A reserve supply was needed to support the United States woolen and worsted industry, since even in peace-time during the 1930's, domestic production in 1940 amounted to only 189 million pounds (figures on a scoured basis). During 1941, consumption rose to 509 million pounds. In actual fact, with ships returning from Australia, to which they had carried war supplies in support of our troops in the Southwest Pacific, there were ample bottoms for bringing over wool, so that by the end of 1943, even after allowing for the large scale consumption in support of military demands, the stockpile had risen to 400 million pounds.

A particularly important action by the United States government which enabled practically every mill in the industry to participate in military production was the recognition of the differences in cost between integrated mills and those which either did not have combing or spinning facilities, and the adoption of a pricing policy giving a differential in price to mills having to go to other mills for wool tops or yarn. By distributing the heavy buying program over the whole industry, all mills were brought into military production quickly, enabling the industry to reach a high level of production in 1942, the first year of the war.[4]

A special problem arose in getting an adequate supply of wool blankets. This requirement was met in part by the conversion of carpet mills which were shut off from supplies of wool for civilian uses, to producing wool blankets. This type of conversion had been contemplated in industrial mobilization planning, and a number of mills were prepared with experience to make this conversion.

In summary, all of the requisite factors necessary to prompt large-scale conversion of this part of the textile industry were present when the attack on Pearl Harbor set in motion the enormous mobilization of military manpower that was undertaken during World War II.

---

4 - Glen F. Brown, "Quartermaster Purchases of Wool Cloths and Blankets for World War II", Textile Series Report No. 1, Office of the Quartermaster General, Washington,D.C. 6 Feb 1946.

Conversion of the Cotton Textile Industry

(Other than Duck and Webbing)

With respect to cotton goods, other than duck and webbing, the same general situation existed as for wool textiles. There were ample stocks of raw cotton, since the carry-over at the end of August 1941 amounted to 12,165,000 bales, and even though this stockpile was reduced during the war, there was still a stock of 11,163,700 bales on hand at the end of the war in August 1945.

Also, as with wool, the build-up period prior to Pearl Harbor had initiated the industry into relatively large-scale production of military textiles, with resulting conversion of a certain part of the industry's manufacturing capacity. Also, many of the textile fabrics required by the military were either identical with or closely similar to corresponding civilian textiles, so that a change-over to military production could be made with a minimum of disruption.

The most important unbalance that occurred was in fine combed cottons, where the military need for heavier fabrics than were normally produced in most fine goods mills, plus the requirement for plied yarns, created a shortage in spinning and twisting capacity. Delays resulting from this situation cannot be said to have been critical, since some substitutions of carded single yarn fabrics were made as on the Army's 8.2 oz. uniform twill, and in general, the industry met the military delivery schedules. It was apparent, however, in 1944 when planning got underway for the attack on Japan, at a time when we were simultaneously involved with the problems of the winter of 1944-45 in Europe, that military requirements had reached the limits of the capacity of the combed goods segment of the cotton textile industry. Fortunately, the war ended before this limitation affected military operations.

Conversion of the Cotton Duck and Webbing Industries

The two other types of textiles where difficult production problems arose during World War II were cotton duck and webbing. Securing the requirements of cotton duck and webbing for tents, paulins, equipage, covers, carrying cases, and the many miscellaneous military requirements for duck and webbing became the major problem of textile supply during World War II.

The basic difficulty was that the cotton duck industry was relatively small and in peace-time did not produce anywhere near the quantities required in time of war. In a sense it resembled the armaments and ship-building industries. Unlike those industries, however, the solution in increasing output did not lie in building large, new production facilities, but in skillful conversion of other mills to the making of cotton duck. A similar problem existed in the narrow fabrics industry which did not produce in peace-time anywhere near the quantities, particularly of heavy webbings, required by the military mobilization.

In addition to the requirement for increased yardage, there was the further requirement that all duck destined for tentage, paulins, and other covers, required fireproofing with the Fire, Water, Weather and Mildew Resistant treatment which had been adopted by the Army in 1941. The finish, developed by Wm. E. Hooper & Sons, Baltimore, Maryland, necessitated the setting up of finishing plants designed to apply the finish from a solvent rather than by wet finishing; also, it required two essential materials: chlorinated paraffin and antimony oxide, the latter having to be imported, with principal supplies coming from Africa. Supplies of both materials were short, together with the copper naphthenate later added to provide mildew resistance. Furthermore, the technology was new, many new producers were needed to provide the required output, and, overall, the experience reflected the technical difficulties of going into production on a new textile finish before the process technology had been proved and the product adequately tested. [5]

Since tents were going to have to be required for housing of troops while cantonments were being built in posts, camps, and stations, and for all forms of shelter required by our expeditionary forces, the total requirements were not only great but the need for immediate supply was critical.

Tents supported by poles and pins are the most efficient portable shelter there is with respect to cost, weight and bulk, and also require the minimum transport facilities of any form of shelter. A typical tent, the Tent, General Purpose, Medium, weighs only 0.91 lbs. per square foot of floor area. Tentage thus constitutes an essential requirement for an army moving into combat, particularly in temperate and cold climates, as well as in areas of heavy rainfall in the tropics. This was true in World War II, and is still true — there has been no replacement developed for the pole-and-pin tent that is as efficient for troops in the field.

The existence of the problem of getting an adequate supply of duck was well understood both by the industry and by the military. The Quartermaster Corps had worked out mobilization plans for conversion of mills to producing duck and the industry knew that drastic measures would have to be taken. What neither was prepared for, as the crisis in supply developed, was the impact of separate procurement by each military service, and by the end-item contractors who were to use contractor-furnished materials. The cross-bidding that occurred created inordinate confusion in the industry. On the basis of competitive bidding, a mill might get twenty requests for quotations on an invitation to bid, and might get no sooner warped up to supply one order than it would receive another order with a higher priority.

Fortunately, in February 1942, procurement of all cotton duck was centralized in the Quartermaster Corps for all military and essential civilian use, and procurement placed on

---

5 - J. O. Small, "Duck, Cotton: Fire, Water, Weather and Mildew Resistant", Office of the Quartermaster General, Washington, D.C., Sept. 1945. pp. 10-13.

a negotiated basis. A mill could, in a matter of a few minutes, come out with an order in hand. Prices ranged from the level of the integrated mills to a level some fifty percent higher for the converted mills. The conversion of some of these mills was made possible by the fact that the Japanese conquest of Indonesia and Malaya cut off the supply of crude rubber to the United States, thereby reducing tire manufacturing and making plied cotton yarn manufacturing capacity available for other uses. The 70 million pound capacity for plied cotton yarns of the tire manufacturers could thus be made available to carpet and other mills which had no cotton yarn production of their own. This situation continued into the summer of 1943 when synthetic rubber began to come into production.

The degree and character of conversion for the production of cotton duck is shown in Table V.

TABLE V

SOURCES OF COTTON DUCK PRODUCED IN 1942

Classification	No. of Mills	Tentage and Ounce Ducks (Sq.Yds)	Numbered Ducks (Sq. Yds.)
Cotton and Duck Mills	34	111,345,649	
Carpet Mills	20		21,719,317
Tire Fabric Mills	5		13,142,501
Velvet, Upholstery & Plush Mills	17	19,805,939	
Rayon Mills	1	255,556	
New Duck Mills	1		2,000,000
Paper Weavers	1		987,778
Woolen Mills	2	590,000	
Yarn Mills	1		73,832
Total	72	131,997,144	43,064,462

Total Yardage -- 175,064,462

Source: The Quartermaster Duck and Webbing Pool, Col. Robert T. Stevens and Ralph A. Butland, Office of the Quartermaster General, Washington, D.C., Feb. 1, 1944. p. 1

From the above, it will be noted that 63,718,813 yards, or approximately 36% of the total procurement came from converted sources. In addition, a substantial part of the tentage duck came from mills which did not ordinarily make duck.

It should be noted also that many substitutions were made for cotton duck. Thus, flat ducks (single yarn fabrics) were used in the side-walls of tents to reduce the demand for plied yarn fabrics; lighter weight ducks were adopted for heavier fabrics wherever possible, and a 10.6 oz. twill was produced as a substitute for duck for tentage. Unfortunately, it lacked the tightness essential for tent fabrics, and tents made from it leaked.

In October 1942, a Duck and Webbing Pool was established with a revolving fund of $200,000,000 with authority to purchase fabrics not against specific requirements, but against the best estimates of needs, and with the pool stocks to be merchandised on a revolving basis. The operations of the Quartermaster Corps on cotton duck, including those of the Duck and Webbing Pool, over a two-year period, January 1942 to January 1944, involved a procurement of 720 million yards; shipments and allocations for use during that period of 700,000,000 yards, with a remaining inventory of all types of 20,0[illegible],000 yards on hand. [6]

The importance of operating controls of the type established in the Duck and Webbing Pool is clearly brought out when consideration is given to the unplanned requirements that developed and which must always be expected on a multi-use material like duck. During the year 1943 alone, the following unforseen requirements had to be met.

TABLE VI

UNPLANNED REQUIREMENTS FOR COTTON DUCK — 1943

User	Quantity (yds)
Army Postal Service	22,700
Marine Corps	1,097,232
Maritime Commission	1,677,668
Navy Department	20,037,698
Panama Canal	1,850
Quartermaster Corps	3,563,808
Red Cross	100
Strategic Services	5,888
Treasury	4,302,830
War Aid	28,225,983
Total	58,935,757

Source: The Quartermaster Duck and Webbing Pool, Col. Robert T. Stevens and Ralph A. Butland, Office of the Quartermaster General, Washington,D.C. Feb. 1, 1944. p. 23.

6 - Col. Robert T. Stevens and Ralph A. Butland, The Quartermaster Duck and Webbing Pool, Office of the Quartermaster General, Feb. 1, 1944. p. 36.

The effectiveness of the Duck and Webbing Pool in getting supplies of grey goods into production did not, however, of itself solve the problem of getting tents into the hands of troops, or even of getting fabric into the hands of tent fabricators. The need to build-up a finishing industry to apply the FWWMR finish was another problem. The time involved in getting textile materials through the manufacturing process for delivery as finished materials is well illustrated in Figure 5. This chart was prepared at the Jeffersonville Quartermaster Depot at the end of World War II to make a permanent record of the time required to produce finished tent fabric.

Here it will be noted that it was the procurement in September 1941 that started the production of the FWWMR finished cotton duck. Large procurements did not occur until April 1942, and it was not until six months later that production hit a peak. Allowing three additional months as the minimum for fabrication of tents, this would mean that the big quantities of tents required in support of mobilization did not begin to come out of production until the Fall of 1942 and the Winter 1942-43, almost a year after the war had commenced.

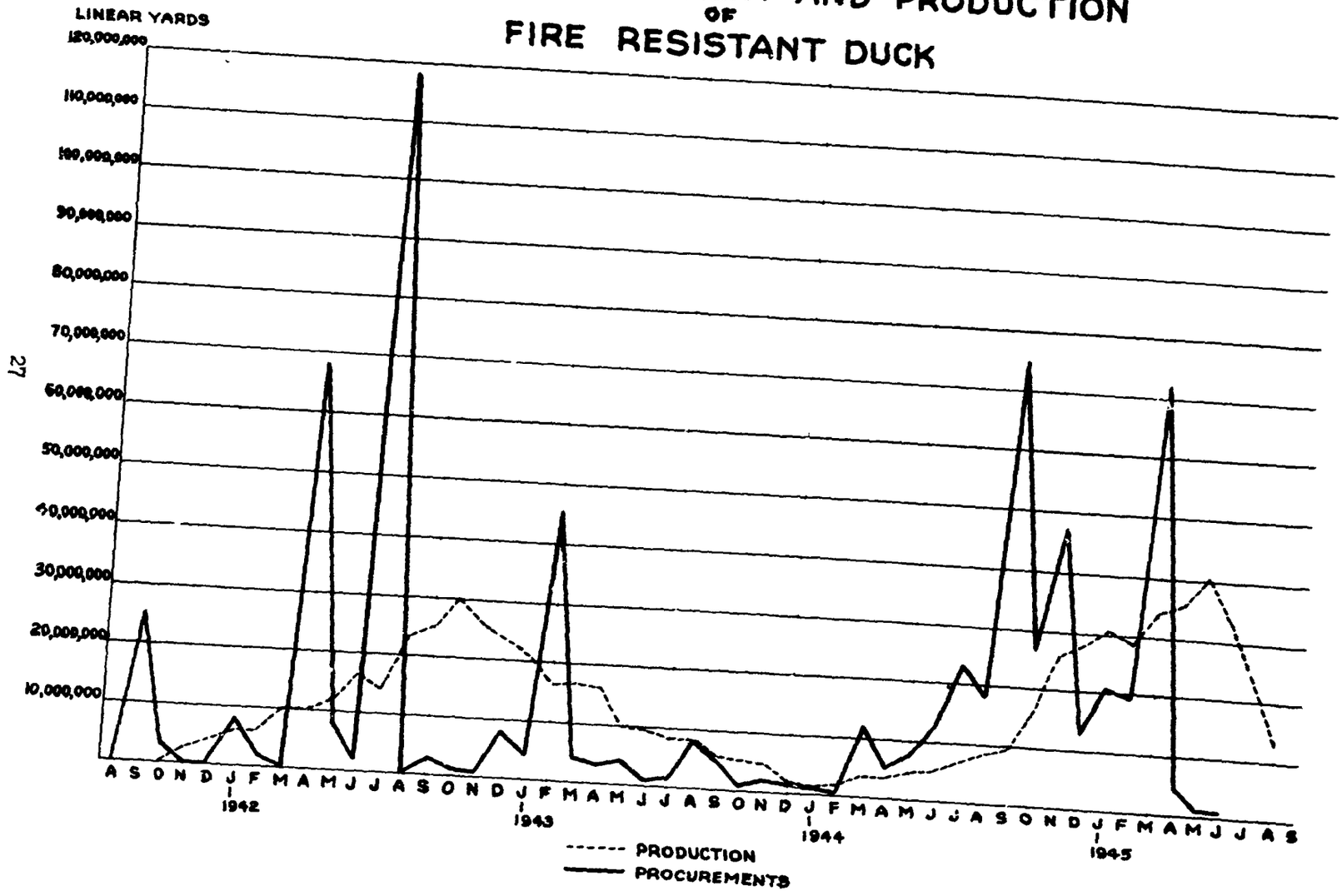
It should also be noted that following this big peak, the industry was largely shut down in late 1943 and early 1944, until new requirements came for the support of the invasion of Japan and for replacement of tents that had failed in field exposure and use. Again, it was nine months from the placement of the big procurement in September 1944 before the production of the finished FWWMR duck reached its peak. However, some sizeable quantities became available within two months after the placement of the contracts. This was possible because the Duck and Webbing Pool held stocks of grey goods which could be immediately put into finishing. Where grey goods had to be produced, the time period was longer. It should also be noted that in order to manufacture tents, priority production had to be initiated for long-arm sewing machines, since there was not an adequate supply of these machines in the canvas goods manufacturing industry.

It must be kept in mind that the tent problem will always be with us in any future mobilization. There will always be need for shelter in the field just as there will be a requirement for food, for motor fuel, for weapons and ammunition, and for clothing. The requirement for portable field shelter may be minimized in the tropics, but in colder climates, field shelter must be available. Assuming the availability of local housing for troops and supplies, for hospitals and headquarters operations involves uncertainties and risks that cannot be made part of long-range planning.

Accordingly, this problem of making provision for the availability of large quantities of a fire resistant, water resistant fabric that can be used in tents constitutes a major challenge to the textile industry and to military research and development, particularly since the trends in the industry point toward further reduction in the manufacturing capacity for producing the kinds of fabrics which have met this need in the past.

FIGURE 5

MONTHLY PROCUREMENT AND PRODUCTION OF FIRE RESISTANT DUCK



The problems of supply of webbing, while similar in character to those on cotton duck, could not be solved by conversion alone but only by the production of additional webbing looms. Since the major shortage was in heavy webbings for parachutes, machine gun belts, equipage, and similar uses, it was essential that additional heavy webbing looms be produced as quickly as possible. There were only two webbing loom manufacturers in the United States — the Fletcher Works, Philadelphia, Pa., and Crompton & Knowles Loom Works, Worcester, Mass., having a combined maximum production of about five looms per week. That production rate, however, could not be reached for at least ten weeks. A total of 28 looms was approved for purchase but delivery to contractors manufacturing webbing was not completed until October 1942. [7]

A significant conversion program was carried out to convert the elastic webbing manufacturers to producing webbings for military uses, since otherwise they would have had to shut down due to cut off of their supply of rubber for elastic thread.

This summary of textile industry support of military mobilization during World War II illustrates three things in particular: the difficulties involved in meeting military requirements where there is only a small industry production base in peace-time; the necessity for planning how to meet the requirement through prior development of alternate materials and adequate planning for the converting of mills quickly to making a product they are not normally prepared to make.

---

7 - Col. Robert T. Stevens and Ralph A. Butland, The Quartermaster Duck and Webbing Pool, Office of the Quartermaster General, Feb. 1, 1944. p. 44.

The Korean War

Supply support on textiles and clothing during the Korean War operated under circumstances which were markedly different from those existing during World War II. A review of the response made by the textile industry to the mobilization requirements should take into account especially the following aspects:

— The suddenness of the outbreak of the war and the rapidity of its intensification during the first year. The war broke out without warning by invasion of South Korea on June 25, 1950. The Inchon landing was made on September 25, 1950, followed by the allied advance into North Korea. Then in November 1950, the Chinese Communist counter-thrust began, with the Allied forces being thrown back into South Korea. By June 1951, the front had been stabilized around the 38th parallel, and for the following two years, until the armistice was negotiated in July 1953, the conflict was characterized by position warfare.

— The limited extent of mobilization of the armed forces. As pointed out earlier. the U.S. military forces were about doubled during the first year of the war and were not greatly increased above that level: from 1,460,261 in June 1950, to 3,249,451 a year later, and only 3,635,912 at the peak in June 1953.

— Requirements of the Korean climate for extreme cold climate clothing during the winter. This clothing utilized wool insulating layers which necessitated substantial purchases of wool cloth.

— The absence of price controls early in the war which, coupled with anticipated purchases of wool cloth and a wool reserve, led to a speculative rise in the price of wool. The price of wool skyrocketed from $1.21 in the recession of mid-1949 to $3.31 per pound (scoured basis) in January 1951 when trading was suspended on the New York Exchange. The price of cotton also rose from around 30 cents in mid-1949 to over 45 cents in January 1951. (See Figure 6 and Table VII).

— The availability of carry-over stocks from World War II on some items.

— Administrative problems in procurement. Without stressing this aspect, which has been adequately covered elsewhere,[8] it should be noted that during Spring 1950, there had been a considerable reduction in force in the New York Quartermaster Procurement Agency, so that the office was under-staffed when the war broke out, and had lost many of its most competent procurement specialists. Also, regulations were not relaxed to the extent they were in World War II to expedite procurements. Policies required channeling procurement into depressed areas. Then, when the Office of Price Stabilization

---

8 - John V. Haggard, Procurement of Clothing and Textiles, Q.M.C. Historical Studies, Series II, No. 3. Office of the Quartermaster General, Washington, D.C. 1957.

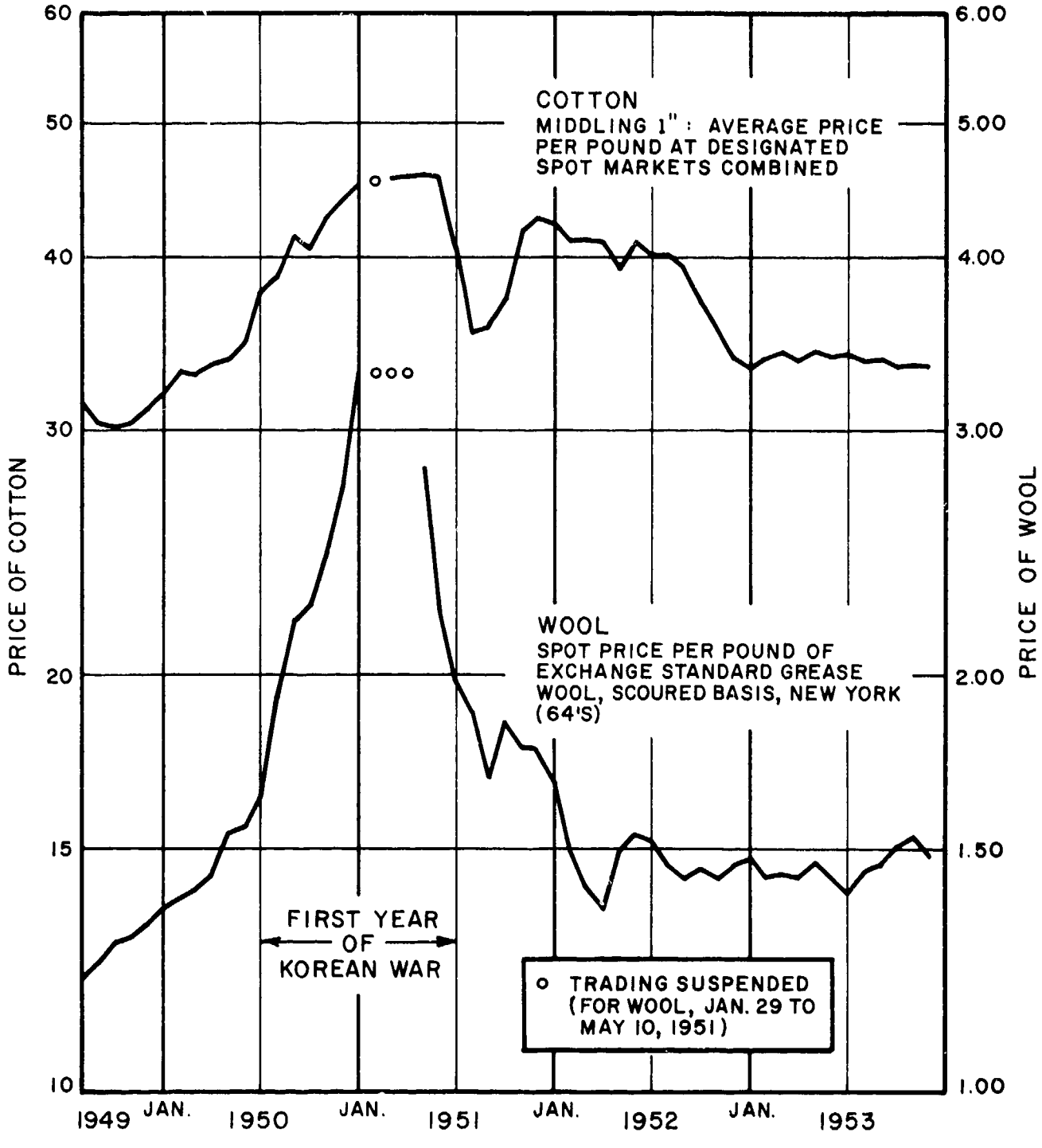


FIGURE 6 PRICES OF COTTON AND WOOL DURING THE KOREAN WAR

TABLE VII

PRICES OF COTTON AND WOOL DURING THE KOREAN WAR

Cotton[1]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1950	32.02	33.01	32.96	33.48	33.91	34.74	37.89	38.71	41.31	40.49	42.92	43.29
1951	44.68	*	45.80	45.84	45.90	45.88	40.59	35.42	35.56	37.42	41.88	42.64
1952	42.33	41.05	41.24	41.22	39.20	41.20	40.17	40.20	39.50	37.24	35.39	33.81
1953	33.34	33.86	34.21	33.93	34.29	33.99	34.14	33.77	33.60	33.47	33.53	33.42

Wool[2]

1950	135.1	135.8	140.0	143.7	154.5	155.7	164.3	193.5	219.4	225.1	245.1	274.1
1951	331.1	*	*	*	282.8	220.7	199.6	187.0	159.1	185.6	177.5	177.4
1952	167.0	150.1	140.7	135.6	149.0	153.9	151.9	145.7	143.3	145.2	143.3	146.0
1953	148.0	142.6	143.9	144.2	147.0	143.2	139.5	145.1	145.9	152.1	153.1	148.9

Source: Cotton — "Statistics on Cotton and Related Data, 1930-67"
Wool — "Wool Statistics and Related Data, 1930-69"
US Department of Agriculture, Economic Research Service, Washington, DC.

1 — Cotton, American Middling 1", average price per pound at designated spot markets combined, by months.

2 — Wool, Spot price per pound of exchange standard grease wool, scoured basis, New York, by months.

* — Market closed.

tried to halt the inflationary rise of cotton and wool prices by placing ceilings on prices paid for military fabrics, industry was unable to bid. Time was lost in resolving this problem. In February 1951, the Munitions Board warned that because the equipping of inductees was seriously threatened, "Planned increases of Army inductees have already been stopped". [9]

It should be added at this point that ultimately, in May 1952, all procurement of textiles and clothing was brought under a single agency, the Armed Services Textile and Apparel Procurement Agency (ASTAPA) at 16th Street in New York. As will be evident from the stress which has been placed here upon industry response during the early stages of mobilization, this action came too late to solve the most critical problems involved in bringing the production potential of the industry to bear upon the needs of the military.

The aspects of industry response of most interest to this study relate to the timeliness of industry production and the readiness of industry to meet a sudden demand where war broke out without warning. Figures 7 and 8 and the accompanying Tables are quite revealing as to the seriousness of the delays in the supply response to the military requirement.

Interpretation of these charts requires some care since the reporting year changed from a calendar year in 1950 to the fiscal year ending June 30 in 1951. Accordingly, the last six months of 1950 is reported twice. On the other hand, since only annual data are available, it is possible to get some picture of what happened during the first six months of the war — the period from July to December 1950.

It will be evident from Figure 7 which shows deliveries of textiles direct to the Army Quartermaster Corps for use as government furnished materials, that no supplies of any size were received during the entire year 1950, which would include the last half of that year. Quite obviously, most of what is shown as delivered during FY1951 therefore came in the last half of that year, or after January 1951. It is clear that a backlog of demand for textile fabrics was building up due to delays in production which could not be met until more than a year after the war started, as shown by the fact that the first big deliveries came in FY1952.

The impact of this delay upon end-item production is shown in Figure 8 which shows deliveries of selected end items. Those which have been chosen are basic volume items of clothing and equipment, and some of the figures used represent averages of deliveries on several items in order to reflect as well as possible, a general picture of end item deliveries.

---

9 - Ibid. p. 152. Quotation from letter, John D. Small, Chairman, Munitions Board to C.E. Wilson, Director, Office of Defense Mobilization, 16 Feb 1951.

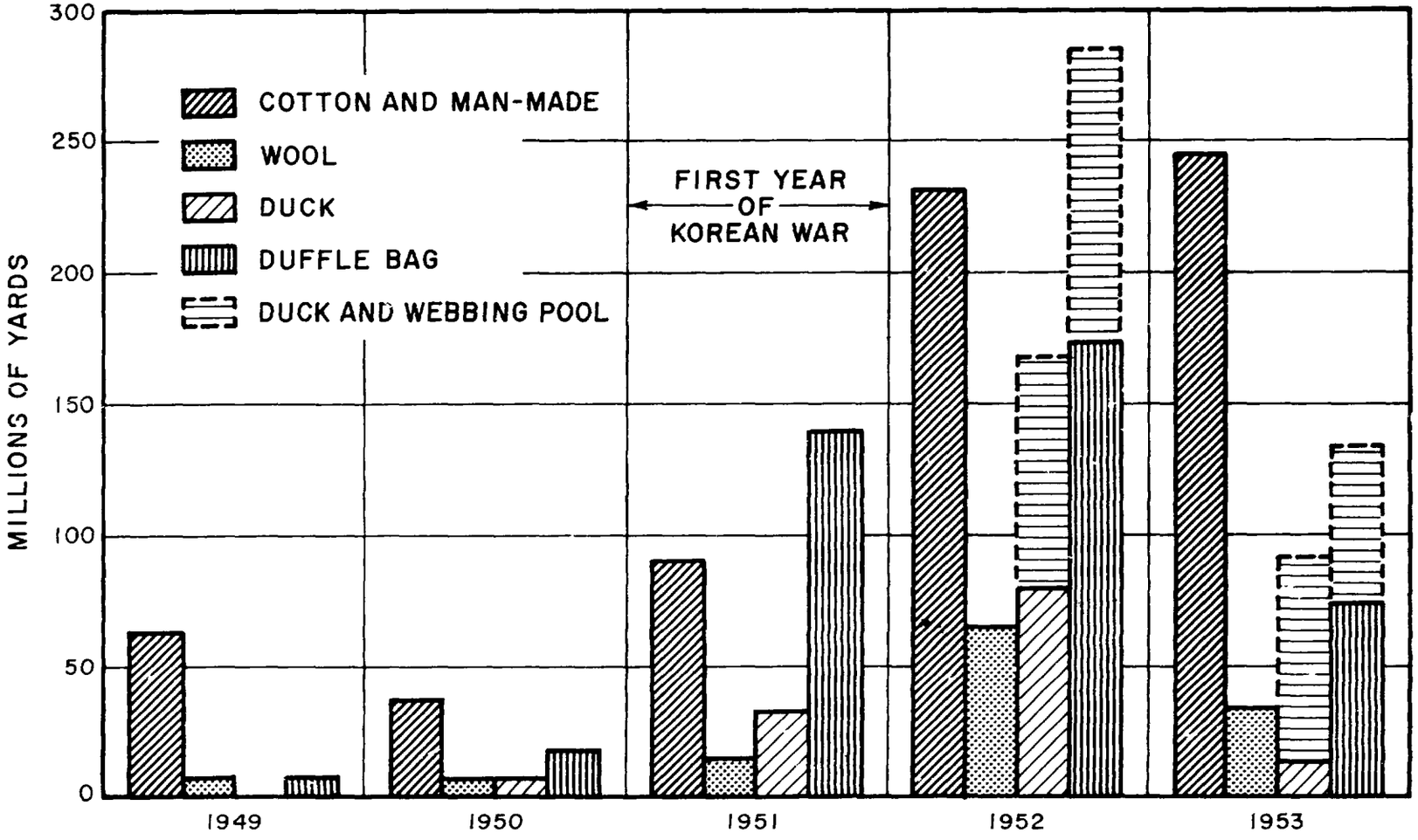


FIGURE 7 DELIVERY OF TEXTILES TO THE QUARTERMASTER CORPS (KOREAN WAR)

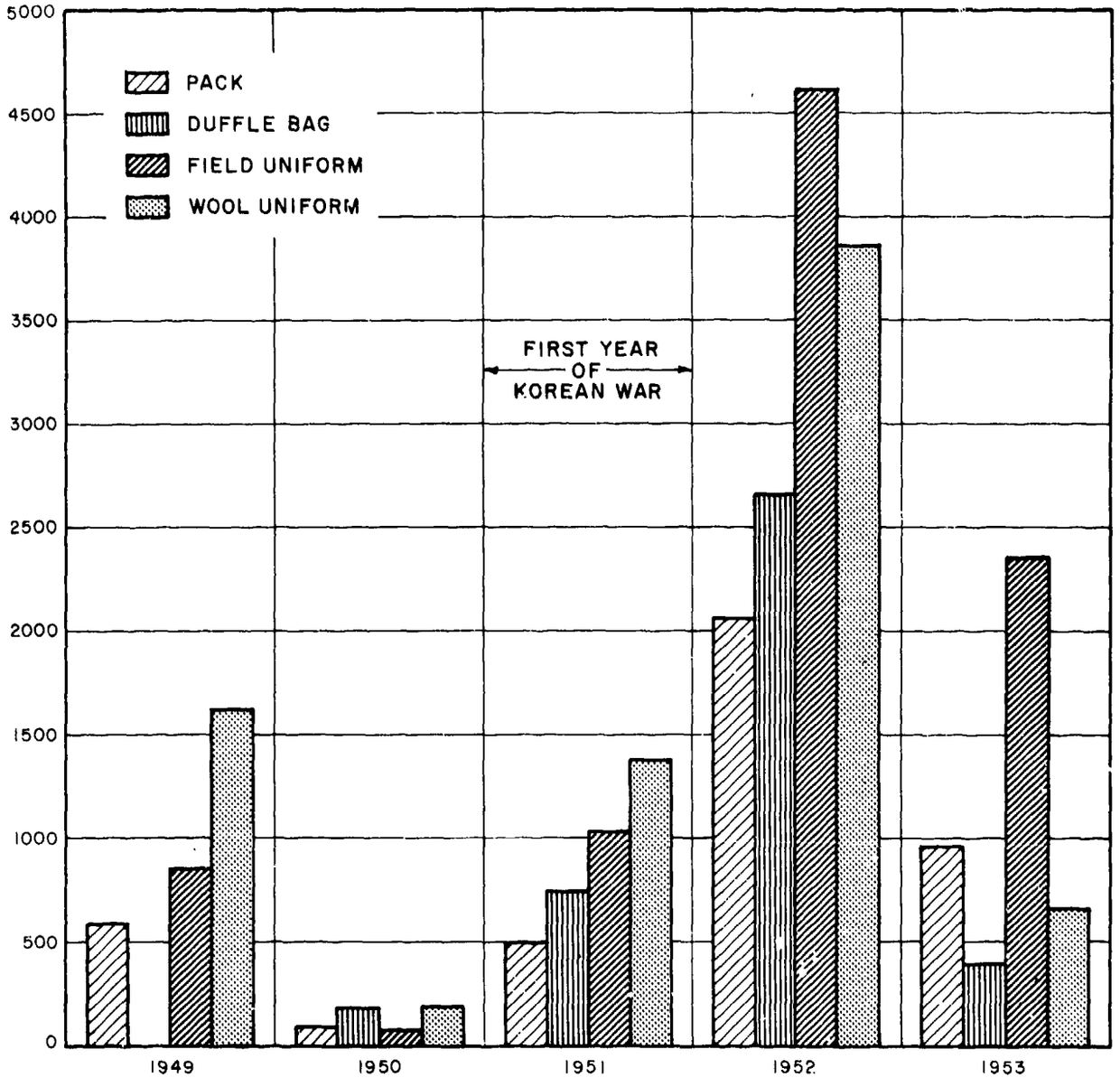


FIGURE 8 DELIVERY OF SELECTED QUARTERMASTER ITEMS (KOREAN WAR)

TABLE VIII

Deliveries of Textiles to the Quartermaster Corps During the Korean War

(000 omitted)

Calendar Year	Cotton & Manmade (Sq. Yds.)	Wool (lin. yds)	Duck (Sq. Yds)	Webbing (Lin. Yds.)
1949	63,334*	6,122	0	7,324
1950	37,837	6,320	6,333	17,946
Fiscal Year				
1951 ***	91,940	15,937	34,963	140,825
1952	233,519	64,322	167,781 (88,115) DWP	286,274 (113,113) DWP
1953	243,007	34,096	93,020 (78,870) DWP	207,412 (133,042) DWP

* Includes 36,529 on yards of 8.2 oz. khaki uniform twill.
*** Includes last six months of calendar year 1950.
DWP -Purchases for the Duck and Webbing Pool.

Source: Statistical yearbook of the Quartermaster Corps, 1950, 1952, 1953. for both Table VIII and Table IX.

TABLE IX

Deliveries of Selected Quartermaster Items 1947 - 53

(000 omitted)

	1947	1948	1949	1950	1951	1952	1953
Average of Three Pack Items (pack combat, pack cargo, suspenders)	44	58	581	87	478	2077	952
Duffel Bag	105	467	0	187	737	2648	372
Average of Six Items of Field Clothing (Winter underwear, HBT shirt & trousers, Field jackets & trousers)	582	1102	844	70	1029	4722	2352
Average of Two Items of Wool Uniform (Jacket & Trousers)	3214	1176	1621	169	1392	3858	656

Notes: 1947 to 1950, calendar years; 1951 - 53 Fiscal years. Dates for F/Y51 includes deliveries during last 6 months 1950 C/Y. 1947 - June 49 includes allocations for Army, Air Force and civilian component; July 1949 to 53 for Army and civilian components only.

Here again, and even more dramatically, is shown the delay in obtaining supplies for support of troop mobilization during the first six months of the war, the last half of the calendar year 1950, and the relatively small supplies during the second six months of the war.

As in World War II, the critical areas of supply were again wool fabrics, fine combed cottons, and duck and webbing. With respect to the problems on wool textiles, there was first the initial absence of price control. This stimulated the price rise that later got out of control when the Chinese Communists entered the war in November 1950, creating concern that a Third World War was in the making, and that an all-out military effort might be required. The wool textile requirements were augmented by the cold climate of Korean winters, and then there was the concern about wool supplies which led to the decision to stockpile 100,000,000 pounds of wool, part in fabrics, in order to reduce the time lag in production in case the war escalated, and part in raw wool. So far as industry manufacturing capacity was concerned, there were no significant problems, other than those created by the policy to channel contracts to mills in depressed areas and the delays involved in resolving contract prices.

On fine combed cottons, no serious problems arose in obtaining supplies once contracting got underway. However, in duck and webbing the same shortages developed as had arisen during World War II. The carry-over of stocks in the Duck and Webbing Pool from World War II helped out in the early stages of the war, but on new procurements the imbalance between demand and available supply was again evident.

The details of the procurement operation on duck and webbing are adequately covered in QMC Historical Studies, Series II, No. 3, referenced above.[10]

Mention should be made of the fact that during 1951, consideration was actually given to purchase of duck abroad and preliminary inquiries were made of plants in England, West Germany and Italy. Also, there was conversion of carpet and other textile mills again. By the end of 1951, 31 integrated mills had been supplemented by 66 converted plants. The converted plants accounted for approximately 100,000,000 yards of the year's total production of 180,000,000 yards purchased by the New York Quartermaster Procurement Agency.[11]

By directive of the Munitions Board, a duck and webbing pool was established on 3 April 1952. The objectives of this Duck and Webbing Pool were different from that of the Pool established during World War II. In addition to dealing with the current supply problem, it was visualized as constituting an operating reserve for immediate availability

---

10 - Ibid. pp. 60-73.
11 - Ibid. pp. 68-69.

in case of unforseen requirements, emergencies and mobilization. Its objective was, accordingly, to have on-hand a balanced stock of duck and webbing which would be adequate to supply all military requirements, for an estimated six month period following mobilization. It was planned that as stocks were turned over to a using military agency, that agency would reimburse the Pool and these funds would then be reinvested in more duck and webbing.

The original concept of the Duck and Webbing Pool was not to buy a stock of duck and webbing to be set apart as a mobilization reserve, but rather to use mobilization requirements as a gauge to determine reasonable stock levels to be maintained. If war should break out, stocks on hand and due in to the Pool would be available which would add depth to the mobilization reserve. [12]

It should be noted that after the Korean War passed and military demand for duck and webbing declined, the original concept of the Pool became superseded by the problem of carrying such a large capitalized stock, particularly after the creation of the Defense Supply Agency. With emphasis upon turn-over of stock and reduction of capital assets in supplies, pressure built up to utilize these stocks and to reduce the Pool assets.

To make it clear that the production of cloth in weaving mills does not of itself meet the entire requirement, it should be pointed out that an equally critical problem in supplying duck for tentage and covers was the supply of the antimony oxide and chlorinated paraffin needed to apply the Fire, Water, Weather and Mildew Resistant Finish (FWWMR). Also, some of the duck could not meet the minimum water resistance requirements after finishing. There was a further problem of supplying the mildew inhibitor for dyed duck for equipage. The supply problems in this area proved to be the source of further delays in getting end items into the hands of troops.

Altogether, it will be apparent from a detailed study of the Korean War supply operation in this area that, should our country be confronted at some future date by a similar sudden outbreak of a war, if the procurement/supply/mobilization operation could not be handled with less confusion and delay than characterized what was done in 1950/51, there could be an actual breakdown of supply of textiles and the end items made from them. The long time lag in getting new supplies into the system would far exceed any conceivable reserves. The most disturbing aspect is that from the industry standpoint there was no real production problem, other than on cotton duck and webbing. There were adequate supplies of raw material to be had: the cotton carry-over August 1950 was 6.8 million bales; world wool supplies were around their all-time high of 4 billion pounds (grease basis). The wool textile industry had large unused capacity and, except for duck, there was ample capacity elsewhere in the textile industry. If, under such conditions which can probably never be duplicated again, there were supply failures, the need for effective mobilization planning in the future with specific plans to eliminate the kinds of delays that occurred during the Korean War would certainly be needed.

12 - "Questions and Answers Regarding Department of Defense Duck & Webbing Pool," dated 7 March 1952. A memorandum prepared for a meeting in Office of the Quartermaster General with Under-Secretary of Army and members of The Munitions Board.

The War in Southeast Asia

Our involvement in Southeast Asia which had been gradually increasing prior to 1964 was deepened following the attack by North Vietnamese patrol boats on two United States destroyers in the Bay of Tonkin in August 1964. Following this attack, there was the movement of North Vietnamese forces into South Vietnam and in February 1965 an attack upon U.S. bases at Pleiku in the Central Highlands and at Nha Trang on the coast. In June 1965, U.S. troops of all services in Vietnam numbered some 50,000 men. Soon thereafter, however, within 120 days, we had moved over 100,000 men into Southeast Asia. By December 1966, the number of troops in that area had passed the 400,000 mark.

This build-up came at a time when the stocks of clothing and textile items held by the Defense Personnel Support Center were relatively low. There were only limited mobilization stocks, primarily because of budgetary limitations. Furthermore the clothing industry was enjoying an exceptional boom, and manufacturers were reluctant to bid on government contracts.

Notwithstanding the increased pace of procurement to support the escalation which began in mid-1965, the military requirement did not place a serious strain upon the textile industry. Actually only a relatively small part of the industry became involved in supporting military procurement. Even the erosion of production capacity in the three critical areas of wool textiles, fine combed cotton goods, and cotton duck, which accelerated during this period, did not cause serious limitation upon supply of military requirements. Despite the fact that 1966 was a year of very strong civilian demand, the textile industry met all requirements placed upon it without recourse to rated orders. Even in end item manufacturing, where rated orders had to be issued, the problems of obtaining requisite supplies were not of a character that could be considered as presenting any important lessons in respect to some future mobilization, other than the need to simplify administrative aspects of procurement in order to shorten the time required for award of contracts.

There is one important lesson to be learned from the Vietnam War, however, and that is that such a conflict should not be regarded as an archetype of any future mobilization. With the historic tendency to prepare for the future in terms of the last war, it could be disastrous to assume that because no serious supply failures in the areas of textiles, clothing and equipment occurred while we were in Vietnam, there need be no concern for the future. Rather, the whole array of facts being brought out here points to the concern with which the military should regard the future. The simple fact is that

during the twelve years of the Vietnam involvement the textile industry went through almost a metamorphosis, so that the industry as the military knew it in the early 1960's no longer existed by the time our prisoners of war were released. And with the present pace of change, the industry must be expected to be even further altered or transformed a decade or two hence.

What then are the important facts to be considered with respect to textile industry support of military operations during the Vietnam War? The following are probably the more important:

— The gradualness of the increase of our committment led to a continuing demand which was advantageous to those firms which chose to become involved as suppliers to the military. There was reasonable assurance of a continuing flow of business for those who were prepared to allocate a part of their production capacity to military orders. This situation proved particularly true for manufacturers of end items.

— The base of industry support grew smaller as the war progressed, with fewer firms showing interest in military contracts. Many factors contributed to this development: increases in civilian demand; switching of mills from military types of textiles to others of higher profit or better demand; closing of mills, especially in wool textiles due to difficulty of competing with imports; and the administrative aspects of procurement which led to long delays before awards could be made — small business set-asides, awards to depressed areas, Equal Employment Opportunity requirements, government funding policies, etc., all were frustrating to mills operating in a strong civilian market. By the end of the war only a quite small segment of the textile industry had any real interest in supplying military requirements.

— A crisis in cotton duck for tentage was avoided because of the existence of 25,000,000 yards of tentage duck on hand in 1965 from the Korean War Duck and Webbing Pool, which could be turned over to tent manufacturing when the 1965-66 escalation came. Without this stock, the supply of tentage in the early part of the war would have been a sheer impossibility, considering the changes which had occurred in industry capacity for heavy weight fabrics. Also, by the nature of the military operation in Vietnam, it was possible from the start to meet a large part of the total requirements for shelter with semi-permanent construction. In addition, the containers used for transport of supplies proved to serve very well as shelter, offices, etc, where construction of buildings was not practicable or incomplete. In short, the requirement for tentage was not as great as it might have been in some other area of the world where a different kind of war might have been fought.

— The hot climate in Vietnam throughout the year in almost all areas, in addition to reducing the need for tentage, also reduced the need for textiles for the clothing which would have been required had the war been in a temperate climate with a cold winter, or in any other area of the world where cold climate clothing would have been needed. As pointed out in

Appendix A, the per capita requirements for textiles would have been at least doubled in a cold climate area.

In addition to the above factors, it should be noted that due to accelerated research and development by the military, a whole new generation of clothing and equipment had been developed by the end of the war. This new clothing involved changes in fibers and fabrics, as well as in end item design. Some of the changes had been completed before the war got well underway; others were the result of lessons learned as to the needs for improved and more functional items.

Perhaps the greatest motivating force leading to this development program was the stress placed upon reduction in the weight of the soldier's load. This program, known as LINCLOE (Lightweight INdividual CLothing and Equipment) placed stress upon the conservation of the energy of the combat infantryman through reducing the weight of everything he wore or carried.

Among the items affected were the soldier's load carrying equipment. In place of the 9.85 oz. cotton duck used for the pack, a 7-1/4 oz. nylon duck was substituted. In place of heavy cotton webbings, nylon tapes were adopted. This change reduced the weight of this equipment from 5.15 to 3.3 pounds when dry, and even more when wet, since the nylon would not absorb water. Other changes included the adoption of a molded polyethylene plastic case for carrying the new folding entrenching tool, in place of canvas and webbing; the adoption of a polyester batting liner for the poncho as a replacement for the wool blanket; the adoption of an all man-made fiber sweater-sleeping shirt for one made of wool; a nylon/cotton canvas upper for tropical combat boots in place of leather ; and a lightweight 6 oz. combed cotton poplin for a tropical combat uniform in place of a heavier, thicker carded fabric. All of the above items which got into the hands of the troops during the war proved highly successful.

Other important developments were the fire-resistant uniform for Army aviators, made from a high-temperature-resistant polyamide fiber; also, the body armor made from nylon duck, which was worn in combat, and the armor for aircrewmen utilizing a composite of a ceramic and laminated glass fiber.

The development program which resulted in these drastic changes in the textiles required by the military from the textile industry is still continuing, with equally great urgency. The combat load now carried by the infantry riflemen in hot climates, with present body armor, weighs 49.66 pounds, with an added weight of 29.41 pounds for cold climate areas, and 13.62 pounds additional for extreme cold climates (See Table X). In addition, there are extra loads for specialists in the infantry company, such as radio operators, machine gunners, mortar squads, etc., whereas the maximum desirable load from the physiological standpoint should not exceed a third of body weight or about 52 pounds for the average-size man.

TABLE X

THE LOAD OF THE INFANTRY RIFLEMAN

	Weight in pounds
Weapon and ammunition	19.41
Personal Equipment (Load carrying equipment, plus attached items: one full canteen, entrenching tool, etc.)	10.19
Clothing, Environmental Protective, Hot Weather (Including boots and poncho)	8.12
Personnel Armor (Helmet w/liner; body armor vest)	11.94
TOTAL COMBAT LOAD W/BODY ARMOR	49.66
Existence Load (Poncho liner, 1/3 ration, CW protection, toilet articles, etc.)	11.46
TOTAL LOAD, HOT WEATHER	61.12
Added Weight of Cold Climate Clothing	11.63
Added Weight of Individual Equipment, Cold Weather	17.78
TOTAL LOAD, COLD WEATHER	90.53
Added Weight of Extreme Cold Weather Clothing & Equipment	13.62
TOTAL LOAD, EXTREME COLD WEATHER	104.15
Weight of skis, ski poles	9.75
Weight of snowshoes	4.60

Sources: FM 21-15 "Care and Use of Individual Equipment." August 1972
FM 31-70 "Basic Cold Weather Manual." April 1968

Since energy cost levels are conditioned by the weight of the load carried as well as the work demand level, the reduction of the weight of the load is of necessity a priority requirement in research and development of all equipment and clothing carried or worn by the soldier. On-going programs can be expected to further change the type and character of textiles which will be needed for our military forces in the future, and the pace at which these changes will occur can be expected to be related closely to technological advances in industry as well as to military requirements.

It must be expected, accordingly, that the rate of change in military textiles, which has paralleled in some degree the changes that have been occurring in the industry over the past decade or so, will continue in the future. Thus, mobilization planning will require fluidity and adaptability to change with time. In general, it may be expected that with technology proceeding at the pace now going on in industry, a new generation of military clothing and equipment can be expected about every decade for the forseeable future.

IV. THE PRESENT OUTLOOK WITH RESPECT TO AVAILABILITY OF CAPACITY IN THE TEXTILE INDUSTRY

As has been pointed out above, the problem of direct concern here is the capacility of the textile industry to meet the needs of the Military Services in the event of a rapid mobilization of the nation's armed forces in the 1980-85 time frame.

To give realism to this analysis, it has been assumed that mobilization would come suddenly after a period of prolonged peace, and that the mobilization of military manpower would necessitate an increase in the military forces by as much as 100% or more during the first year. While these assumptions have no validity as a forecast, they are not unreasonable in relation to the uncertainties of the international political situation and would be in keeping with the necessities of maintaining a viable military posture. Quite obviously, different assumptions could just as well be used. These have the value of being intermediate between a total mobilization such as characterized World War II, and the limited and gradual build-up which occurred in Vietnam. For purposes of weighing the capabilities of industry support, they provide a reference point from which the changes taking place in the industry can be evaluated.

Just what mobilization reserves might be available on M-Day and for how long a period they could meet the requirements of the troop build-up and actual combat are questions to which there can be no answers. The fluctuations which have occurred in policies with respect to the size of mobilization reserves over the past twenty or more years would not give assurance that after a period of prolonged peace, the available reserves could reduce the dependence of the military upon immediate large-scale production from industry within the shortest possible time frame for both textiles and the end items made from them.

A further consideration which need not be given too much weight, but which should not be overlooked, is the possibility that new weaponry might obsolete the protective capability of whatever reserve materiel might be available, or that advances in technology and in military research and development might cause supplies held in reserve to be technologically inferior to what industry could produce or what might be available to a potential foe.

There are, accordingly, two distinct problems from the standpoint of industry support: Would there be a broad industry base to supply the needed military textiles by immediate conversion on a large scale to provide large quantities quickly? And second, if the conflict were prolonged, would the industry base be adequate to meet the needs both of the military and the civilian population? This second point is not to be dismissed lightly in the light of the experience during World War II. [13]

---

13 - Wilfred Carsel. op. cit.

Furthermore, as has been pointed out in the analysis of the technical requirements for military textiles, by far the largest part of military requirements falls in the field of broadwoven textiles. Our major concern, accordingly, is with respect to the trends in this part of the textile industry.

Broadwoven Textiles

The broadwoven goods sector of the textile industry is highly complex, being comprised of many quite different types of mills and mill equipment. It would be a serious error to assume that because textile production amounts to around 11 billion linear yards per year (11,156.6 million in 1971), the total market is large in relation to potential military requirements, and that, therefore, there need be little concern about military demands being met in case of mobilization.

Table XI shows the breakdown of the total production for 1971 according to the major classes of broadwoven textiles.

TABLE XI

Classes of Broadwoven Textiles

	Production 1971 (Million Lin. Yards)	Percent
Cotton Broadwoven Gray Goods		
Duck and Allied Fabrics	183.6	1.6
Sheeting and Allied Coarse and Medium Yarn Fabrics (except Bed Sheeting)	153.52	13.8
Bed Sheeting	205.2	1.8
Print Cloth Yarn Fabrics	1101.2	9.9
(Carded yarns approximately 28's to 42's; threads per sq. in. 85 and above.)		
Tobacco, Cheese, and Bandage Cloth (Threads per sq. in. 84 and under)	1262.4	11.3
Carded Colored Yarn Fabrics (Denims, Chambrays, etc.)	438.7	3.9
Toweling, Washcloth, Dishcloth fabrics	552.0	4.9
Blanketing & Other Napped Fabrics	126.1	1.1
Fine Cotton Goods		
Combed	156.5	1.4
Fine Carded	39.0	.4
Other Woven Fabrics and Specialties (Bedspreads, Drapery, Upholstery, Corduroys, Velveteens, Damasks, etc.)	538.1	4.8
	6156.7	55.2
Man-Made Fiber Broadwoven Gray Goods		
100% Filament Yarn Fabrics	1416.6	12.7
100% Spun Yarn Fabrics & Blends (Chiefly Manmade Fibers by weight; except bed sheeting)	2319.0	20.8
Bed Sheeting	459.3	4.1
Combinations & Mixtures of Filament and Spun Yarn Fabrics	449.3	4.0
Blanketing, Silk, Pile & other speciality fabrics	228.2	2.1
	4885.7	43.8
Wool Broadwoven Goods		
Woolen Apparel Fabrics	76.4	0.7
Worsted Apparel Fabrics	33.2	0.3
Non-Apparel Fabrics	4.3	—
	114.2	1.0
Total Broadwoven Textiles (1971)	11,156.6	100.0

Source: US Bureau of the Census

Note: Totals of classes do not equal totals by groups; some figures are withheld to avoid disclosing figures of individual companies.

Despite the overall size of the industry, much of the total capacity is not prepared to produce textiles conforming to military requirements. Military textiles are concentrated in the following classes of products:

TABLE XII

BROADWOVEN TEXTILES

CLASSES OF MAJOR MILITARY IMPORTANCE

Class	Principal Uses	% of Total 1971 Production
Duck and Allied Fabrics	Tents, Paulins, Covers	1.6
Sheeting & Allied Coarse and Medium Yarn Fabrics	Utility clothing, misc.	13.8
Fine Cotton Goods (Combed)	Lightweight, tightly woven fabrics for water-repellent clothing	1.4
100% Filament Yarn Fabrics	Parachute canopy, body armor	12.7
100% Spun Yarn Man-Made Fiber Fabrics & Blends [14]	Durable-press uniforms, tightly woven fabrics	20.8
Worsted Apparel Fabrics	Uniforms	0.3

From the standpoint of military requirements, the classes of most critical importance at this time, in terms of the volume that would be required in a mobilization, are duck — 1.6%; fine cotton goods (combed) — 1.4%; and worsteds— 0.3%. The current production rates in these classes, as shown in Table XI, are quite limited and, in addition, they are in a downward trend. Requirements for fabrics in the sheeting yarn fabric class would be considerable, and could undoubtedly be met, although production in this group of mills has also been in a downward trend. Requirements from the mills making blend fabrics are at present concentrated in the finer yarn mills. It can be expected that an increased proportion of total military requirements will be made from blended fiber fabrics in the future.

In general, it would not be practicable or in some cases even possible to produce military type fabrics in most classes of mills other than those listed in Table XII. The costs in conversion of such mills in loss of production, where conversion might be even possible, could be excessive and undesirable from the standpoint of the total war effort.

---

14 — (With respect to the 100% spun man-made fiber and blend class, it should be noted that this class spans a wide range of materials, since the common denominator is simply a spun yarn with 50% or more by weight of man-made fiber - cellulosic or non-cellulosic. The fabrics grouped in this class range from the equivalent of fine cotton goods (combed) through print cloth yarn fabrics down to and including sheetings.)

The Impact of Imports

The impact of imports during the past fifteen years is nowhere more dramatically shown than in the case of woolen or worsted fabrics, with worsteds hurting the most. Figure 9 and Table XIII show the extent of the liquidation of the woolen and worsted industry which has occurred as a result of imports. By 1970 when double-knits rose spectacularly in the men's and women's clothing market, imports had captured half of the domestic market with resulting liquidation of many mills, and had made this area unprofitable because of the lower prices that could be charged on imports from such low wage-rate countries as Japan, Hong Kong and Korea, to the point where continuation of the industry as a viable entity was in doubt.

TABLE XIII

Woolen and Worsted Production and Imports

(Million linear yards)

Year	Production	Imports
1959	311	90
1960	286	111
1961	287	85
1962	310	156
1963	284	161
1964	255	138
1965	267	212
1966	265	204
1967	239	167
1968	243	210
1969	223	191
1970	178	168
1971	113	122
1972	103	125

Source: US Department of Commerce

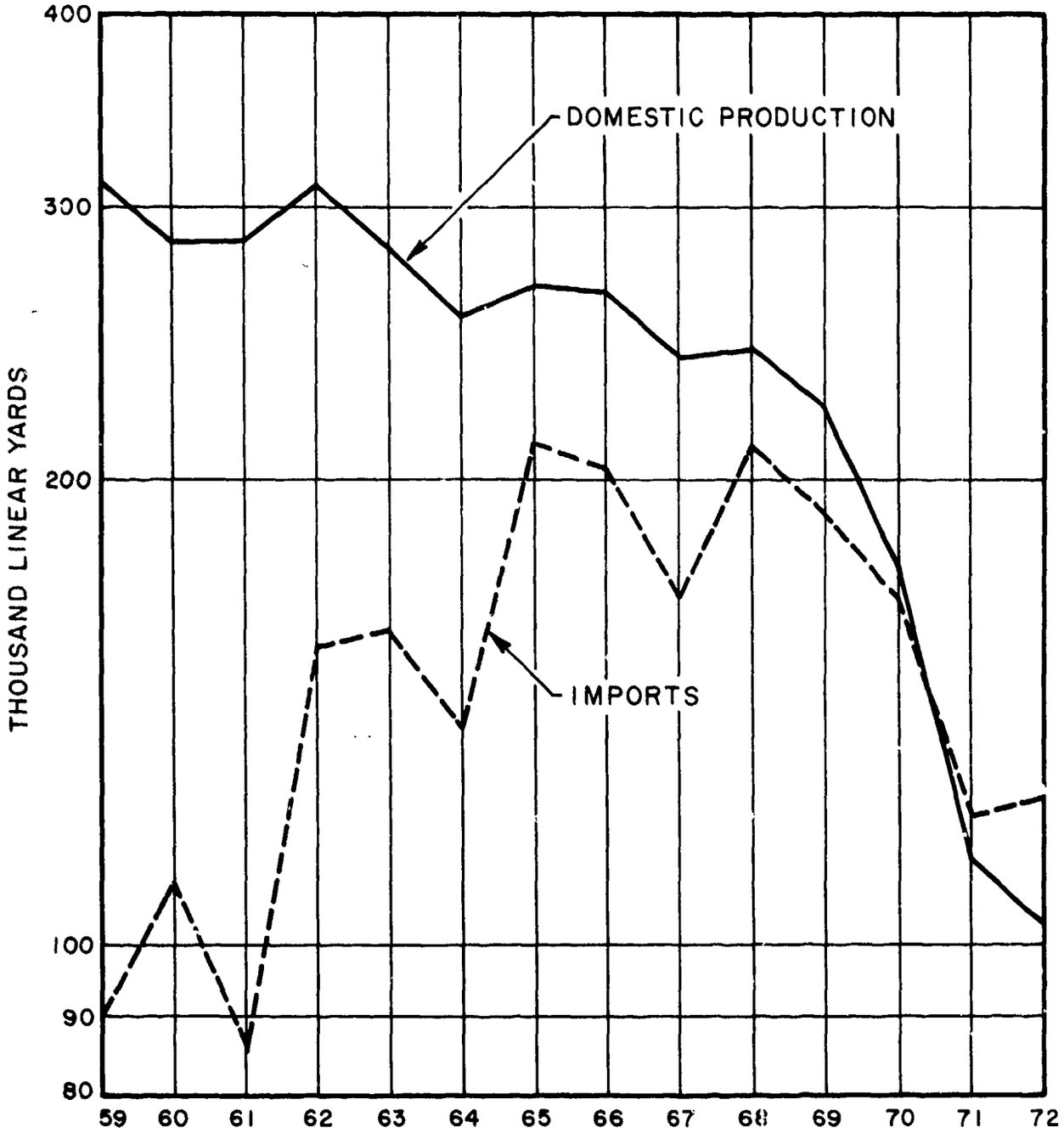


FIGURE 9 WOOLEN AND WORSTED PRODUCTION AND IMPORTS

To those who resort to the claim that the United States textile industry cannot compete because of not keeping its plants modernized, it would be well to point out that in fact the industry has made a very great effort to survive, expending over six billion dollars on new machinery and equipment , new structures and additions during the past ten years.[15]

From the standpoint of meeting military requirements, it is doubtful if what is left of the woolen and worsted industry can continue for the indefinite future, even at its present limited production capacity, or be able to supply even peace-time requirements of uniform fabrics for the armed forces, in the face of the price competition from low wage-rate foreign countries.

While the situation on woolens and worsteds highlights the import situation and its impact upon the United States textile industry, the total impact of imports extends over the entire textile industry and has many implications as to the future potential capacity of broadwoven goods producers. The problems created for the textile industry by uncontrolled and escalating textile imports during the past twenty years are too well-known to require extensive discussion here. The fact that textile imports created in 1972 a balance of trade deficit of $2.3 billion points up the seriousness of textile imports as a national problem,[16] in addition to its direct impact upon potential growth of the United States textile industry.

Partial solutions to the import problem were arrived at in the Long-Term Arrangement Regarding International Trade in Cotton Textiles (LTA), negotiated in 1962 under the auspices of GATT, to which there were 32 signatory governments. The extensions to the LTA, as recently as in 1970, with an increase in the number of participating countries provided at best only a limited solution to the problem as seen by the American Textile Industry. The LTA provides assurance to the exporting nations that expanding markets, as in the United States, will be available to them to furnish them needed foreign exchange earnings.

The more recent bilateral agreements with Japan, Korea, Hong Kong and Taiwan with respect to wool and man-made fiber textiles have slowed down the rate of growth of imports of textiles from those four countries. The most that can be said for these agreements, however, is that they will retard the steady growth of textile product imports without placing any forseeable ceiling upon the extent to which the growth of the American textile market will be given over to foreign imports.[17]

---

15 — US Department of Commerce, Bureau of the Census, Annual Survey of Manufactures, Expenditures for New Plant and New Equipment. Washington, D.C.

16 — US Department of Commerce.

17 — Stanley Nehmer, Deputy Assistant Secretary and Director, Bureau of Resources and Trade Assistance, US Department of Commerce, "Reflections on the Past and Challenges of the Future." Remarks delivered at the New York Board of Trade Annual Textile Award Luncheon, November 27, 1972.

The appraisal by the textile industry that national policy has been pointing toward the turning over of not only the growth in the US textile market to the less developed countries of the world is supported, at least superficially, by the breadth of the international base of textile imports. As shown in Table XIV, 54 countries had exports of over a million square yards of textiles to the United States in 1972. In many of these countries, which fall into the category of "under-developed", the building up of a textile industry has been encouraged as a first step toward industrialization. The technology of textile production is relatively simple and this industry, which is basically labor intensive, is one of the first that developing countries attempt.

Just what the situation on textile imports may be a decade hence is too tied up in international monetary and trade policies to be capable of any forecast. It is not to be expected, however, that imports from the under-developed countries will decline. The ability of the United States textile industry to maintain its present size will depend in considerable part upon whether the growth of imports can be held down to a point where they do not exceed the natural growth of the American textile market.

TABLE XIV

Imports of Textiles — 1972

(Equivalent million square yards)

	Cotton	Man-Made	Wool	Totals
Japan	314.1	1401.2	11.3	1726.6
Hong Kong	488.3	247.4	25.8	761.5
W. Germany	23.9	719.0	2.9	745.8
China (Taiwan)	92.9	592.2	7.6	692.7
Korean Republic	51.3	408.5	11.5	471.3
United Kingdom	13.6	187.7	17.2	218.5
Italy	47.6	141.4	11.0	200.0
Canada	39.7	111.7		151.4
Mexico	96.8	51.0		147.8
India	133.8			133.8
Pakistan	132.4			132.4
Brazil	93.8	14.5		108.3
France	9.3	65.6	4.1	79.0
Belgium	46.2	29.4	3.2	78.8
Israel	7.2	70.4		77.6
Phil Rep	10.8	43.1		53.9
Switzerland	4.4	47.2	1.1	52.7
Colombia	46.9			46.9
Singapor	36.6	7.3	2.8	46.7
Portugal	32.8	9.1	2.3	44.2
Egypt	41.4			41.4
Netherlands	5.7	28.9	1.1	35.7
Ireland		31.8	4.4	36.2
Spain	9.9	22.7		32.6

TABLE XIV

(Continued)

	Cotton	Man-Made	Wool	Totals
Thailand	27.2			27.2
Rep. So. Africa		24.5		24.5
Malaysia	18.4	1.5		19.9
Austria	4.2	9.9	1.9	16.0
Yugoslavia	10.6	2.4	1.0	14.0
Jamaica	6.7	7.2		13.9
China (Mainland)	10.3			10.3
Poland	8.0	1.9		9.9
Finland	3.2	5.2		8.4
Romania	8.1			8.1
Australia		6.1	1.2	7.3
Costa Rica	2.7	4.3		7.0
Denmark		6.6		6.6
Salvador	6.1			6.1
Argentina		5.4		5.4
Sweden		4.9		4.9
USSR	4.5			4.5
British Honduras	2.9	1.0		3.9
Barbados	1.0	2.9		3.9
Ryukyu	3.1			3.1
Lebanon	3.0			3.0
Macao	2.9			2.9
Nicaragua	2.9			2.9
Ghana	2.5			2.5
Trinidad		2.3		2.3
Morocco	1.9			1.9
Peru	1.8			1.8
Turkey	1.7			1.7
Greece		1.5		1.5
Norway	1.5			1.5

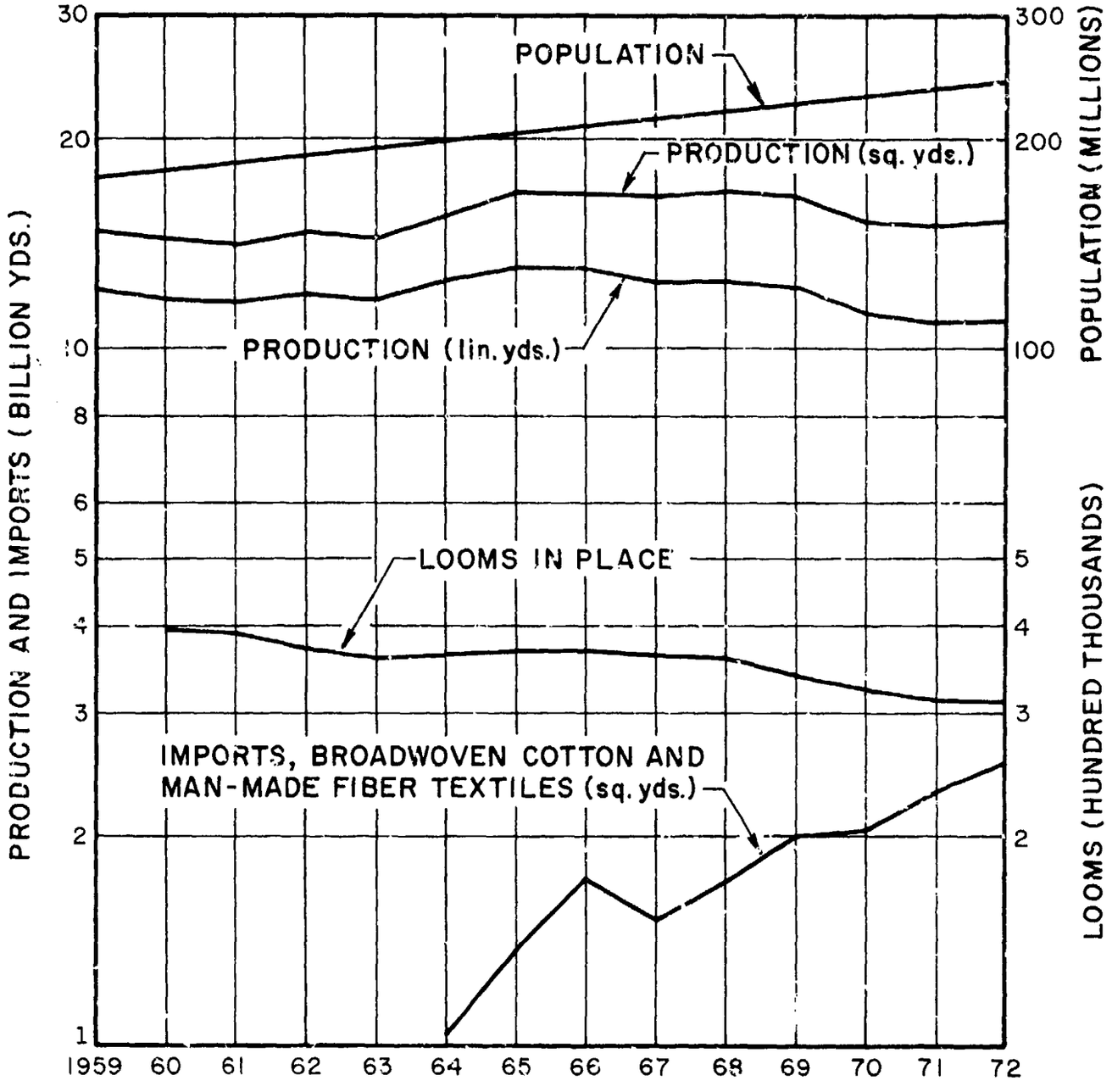


FIGURE 10 COTTON AND MAN-MADE BROADWOVEN GOODS

The Present Outlook for Broadwoven Textiles

Because of the importance of broadwoven textiles in military uses, the fact that this part of the industry is not increasing in capacity proportionate either to population growth or total consumer demand must be a cause of some concern when looking forward to a possible industrial mobilization in an emergency.

As shown in Figure 10 and Table XV, there has been a steady decrease in number of looms from 395,192 in 1960 to 314,590 in 1972.

This decrease in production facilities has been offset, however, by an increase in productivity resulting from installation of wider and faster looms as replacements. The indicated increase in productivity is representative of what has been occurring throughout the textile industry in the effort to reduce costs to meet foreign competition. Figure 11 shows the relative trend in mill consumption of fibers and employment, with employment in the industry dropping from 1,163,400 in 1952 to 991,000 in 1972, while mill fiber consumption rose from 6.4 billion pounds to 11.7 billion. These figures indicate a rise in productivity

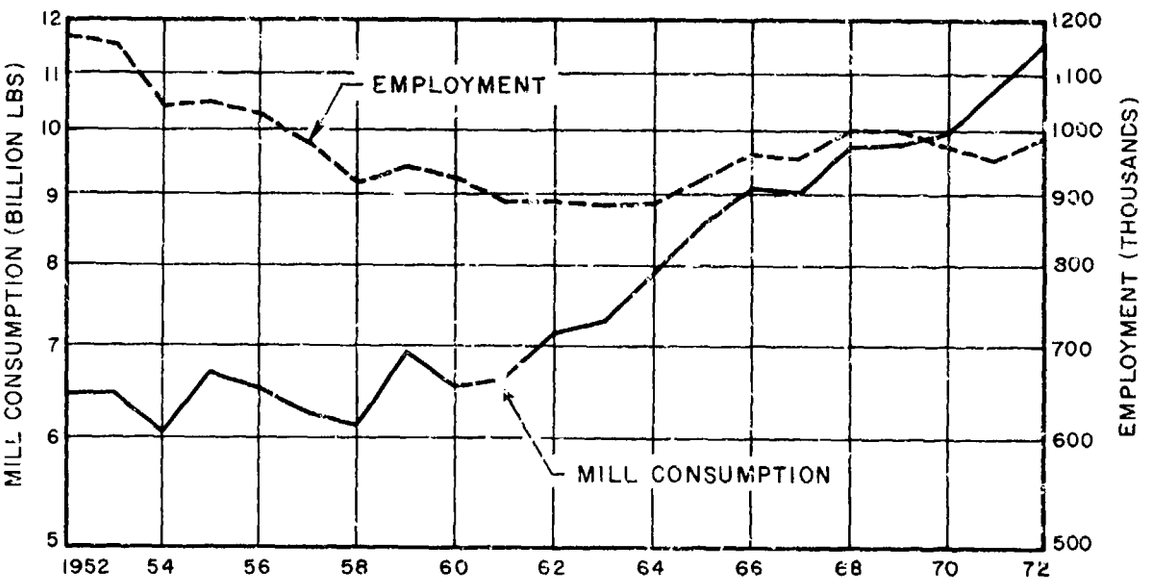


FIGURE 11 PRODUCTIVITY INCREASE IN TEXTILE MANUFACTURING

TABLE XV

Cotton and Man-Made Fiber Broadwoven Goods

	1	2	3	4	5	6	7	8	9
Year	Production Linear Yds. (000,000 omitted)	Square Yds.	Lin.Yds/ Sq. Yds.	% Increase in Sq. Yds	Imports[1] (000,000 omitted)	Exports[2]	Looms in Place (End of Yr.)	Avg. Loom Speed (Picks/Min)	Population (000 omitted)
1947	11,856	13,279	1.12						
1950	12,621	14,388							150,697
1959	12,102	14,643	1.21	8.0					
1960	11,770	14,359					395,192		179,323
1961	11,576	14,123					396,771		
1962	11,991	14,799					373,339	185	
1963	11,820	14,539	1.23	9.8			363,498		
1964	12,511	15,639			1,045.3	578.1	368,968		
1965	13,164	16,718			1,379.7	455.8	370,478		
1966	13,075	16,867			1,746.6	489.1	371,645		
1967	12,546	16,561			1,516.7	443.1	365,941		
1968	12,680	16,991	1.34	11.9	1,736.0	431.9	361,301	190	
1969	12,368	16,637			2,004.2	466.0	342,846		
1970	11,275	15,333			2,036.5	443.6	328,214		203,185
1971	11,032	15,114			2,326.7	465.5	317,752		
1972	11,148	15,496	1.39	24.1	2,583.5	580.8	314,590		
1974								200	
1980									B- 236,725 C- 233,798 D- 230,865 E- 227,765

1 — Imports of Cotton and Man-Made Fiber Broadwoven Fabrics, including import of apparel, made-up goods, and miscellaneous converted to square yard equivalent using U.S. Dept. of Commerce conversion factors.

2 — Exports - Broadwoven piece goods only

from 5,535 pounds per employee to 11,772 over the twenty year period. While this comparison must be used with some reservation, since a substantial part of the increase in fiber use has come from the growth of the floor covering market, they do reflect a genuine increase in productivity as a result of continuing capital investment in the interest of reducing costs and utilizing technological advances.

On the basis of square yards produced, the industry could be said to have held its own, with production in 1972 of 15,496 million square yards as compared with 14,388 million square yards in 1950 and 14,359 million in 1960. The increase in the size of the market which might have resulted from the 13% increase in population between 1960 and 1970, which could have amounted to around 1.9 billion square yards was largely absorbed by imports which increased by one and a half billion yards in the eight years from 1964 to 1972.

In addition, broadwoven textiles have had to face severe competition in the apparel markets during recent years from knitted fabrics, particularly double knits. A major part of the new capital inflow to the industry during the past half-dozen years has been into knitting production equipment.

At the time this report is being written, the entire textile industry, including the broadwoven goods mills, is experiencing a very strong market, with mills sold a year ahead on some items. It might be expected that this situation, resulting in part from the recent devaluation of the dollar, would result in plans for the construction of new producing facilities.

On the contrary, the attitude of mill executives is that the profit margin that can be anticipated in the near future, which will be limited by the competition from the inflow of imports, would not warrant new capital investment in the building of new broadwoven goods mills. This position was summed up in an interview published in the Daily News Record of March 28, 1973, by Mr. Donald Comer, Jr., President and Treasurer of Avondale Mills, and also the President of the American Textile Manufacturers' Institute, when he said:

> "As far as building new mills is concerned, I have always said I would like to be around long enough to see the time when the demand for woven goods was such that it called for the building of a new mill that could be paid for within a reasonable length of time . . . . We are studying at all times the feasibility of building a wovens mills. We have had the opportunity in the past to sell increased production on woven fabrics that we are offering, but when we put the pencil to it at the price we would be getting for the cloth, there is not any way to get your money back within a reasonable length of time."

The view expressed in the above statement had been confirmed by other sources in the industry. It is in keeping with the trend in corporate profits in the textile industry as shown in Figure 12.

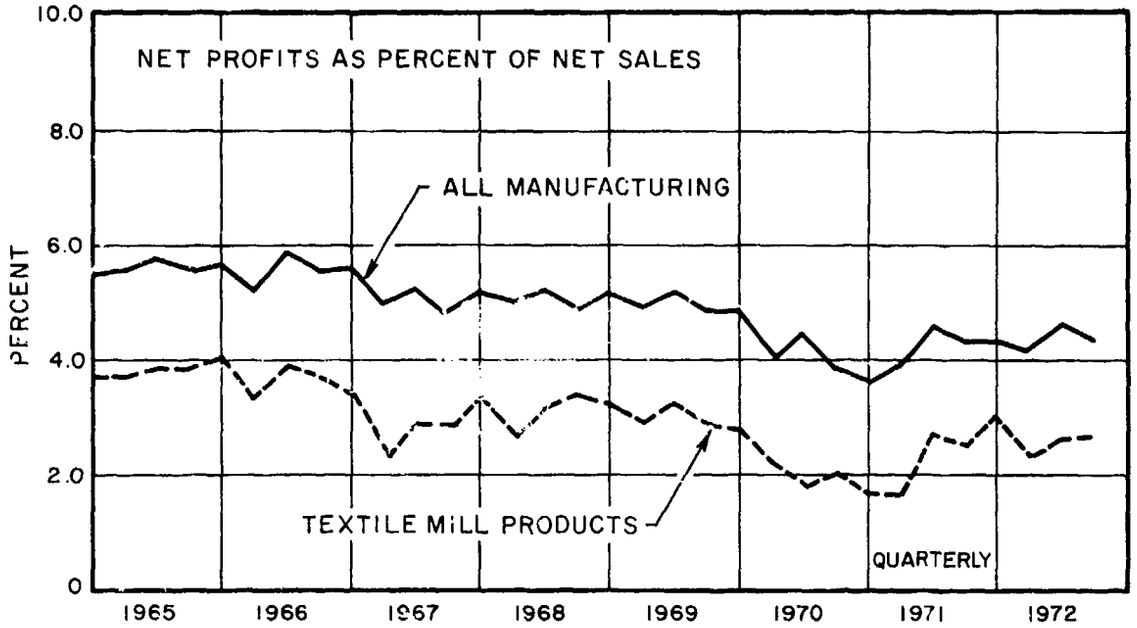


FIGURE 12 CORPORATE PROFIT DATA
(AFTER FEDERAL INCOME TAXES)

While possibly during the next decade there may be a change in the basic economic of the broadwoven goods industry which would permit expansion, the prospect is not promising at this time, and the military should be prepared to have to rely upon an indu try which will be supplying significantly less than the 85% of the consumer market for i products in the United States which it is supplying today. The implications of this situa in the event of any prolonged conflict, with the industry unable to supply essential civil needs on top of military requirements, should be a matter of concern.

Mobilization Aspects

Conversion from civilian to military production, as has already been indicated, has the dual aspect of an immediate broad-scale conversion for the production of large quantities of fabrics and items to support manpower mobilization in the early stages of a conflict. Then there is the later aspect of sustained production if the conflict is prolonged.

With respect to the first aspect, it will be apparent from the foregoing that in the three critical areas of duck, fine combed cotton goods, and wool fabrics, the industry is not of a size that it could even at this time supply more than a fraction of the total requirement of a moderate sized mobilization. The reduction in the number of looms on cotton duck and in fine cotton goods is shown in Table XVI.

TABLE XVI

Looms Operating on Cotton Duck and Fine Cotton Goods

	Cotton Duck	Fine Combed Cotton Goods
July 1950	7,454	68,428
1960	5,663	77,245
1972	3,518	7,831

Source: American Textile Manufacturers' Institute, Inc.

Also, there has been a reduction in the number of mills and total capacity for production of sales yarn which might enable mills to balance their production by the use of purchased yarn. Sales yarn played an important role in all three wars, in providing extra spinning capcity which could be channeled to support mill conversion to military textiles, particularly on cotton duck and fine combed cotton goods. With the continuing down-trend in this segment of the industry, this important capacity may not be available in a future emergency.

To bring mills into production on military fabrics from other segments of the industry will take more time because of the changes that they must make in their operation. For economical production, the equipment in a textile mill is balanced to produce a particular kind or class of fabric. This is especially true with respect to the balance between spindles and looms, the yarn numbers to be spun, the weight of the fabric to be produced, and the grade and staple length of cotton or other fiber to be used. A change in any of these factors can require substantial reorganization of the manufacturing process and cause loss of time and production. Accordingly, it cannot be expected that where mills must convert to a type of product

they do not ordinarily make, they can start producing as quickly as a mill which is already producing that particular type of fabric for the commercial market. Thus, there is a significant factor of delay which would extend beyond the production lead-time that would apply to a mill already producing that class of fabric.

Special manufacturing equipment might also be needed such as combers or twisting spindles for producing plied yarns; also, time to manufacture the equipment and space to install it. Idealized lead time estimates while possible of realization in some mills cannot be considered as a firm base for production where significant conversion is involved. The history of industry production in both World War II and the Korean War amply demonstrates this fact.

There is one useful trend, however, that in time will be to the advantage of the military. That is the greater flexibility of the looms that are being installed in the industry today which can be used to produce textiles made from different fibers and over a wider range of constructions and weights. This breaking down of the compartmentalization that has historically existed between the cotton, the man-made fiber, and the wool textile segments of the industry is leading toward the creation of a single weaving capacity in the industry, with looms able to shift over a relatively wide range of products. There will still be the difference between mills having spinning capacity for producing spun yarns and mills equipped to run only on filament yarns. Where spun yarns would be required, a source for their production would be needed. On the other hand, if filament yarns, such as texturized filament yarns were to be used, it is probable that the fabrics could be produced in almost any weaving mill.

Rapid conversion of the textile industry from commercial to military production within the limited time frame of a relatively large mobilization effort, assuming the kind of patriotic response which this industry has always shown in the past, would be dependent also, in part, upon the relative status of the industry's technology and that called for in the textile materials required by the military at the time. On the one hand this would necessitate a broad-based research and development program by the military to take advantage of all technological developments in industry to keep military textiles in line with industry advances, and at the same time, keeping industry apprised of the escalating demands for improvements in military textiles to meet the demands for protection against new munitions and weaponry of all kinds.

Also, it would require very close contact with industry in order to explore promptly new technical developments which might have military application. Because of the need to adequately test any new material before it could be adopted in a military use, a strong continuing research and development program on textile materials will be particularly critical as the pace of industry technology continues to increase. Whatever may occur during the next decade should be reflected both in assuring an adequate industry base for the production of the required materials, and adequate mobilization planning to assure the shortest possible lead time in the event mobilization becomes necessary.

Textile Machinery

The outlook for industrial mobilization of the textile industry in a national emergency must be looked at also from the standpoint of those industries which provide back-up to it. One of these of particular importance is the textile machinery industry.

In the event of a future defense emergency, the Department of Defense and the U.S. textile industry would be faced with problems relating to textile machinery that would be unique to their past mobilization experiences. All prior crises found the United States textile industry with some reserve fabric capacity and equipped with machinery supplied by a relatively few United States producers.

As already pointed out, the U.S. textile industry does not have ample reserve capacity to meet large demands for military fabrics, nor can it add machinery from United States sources to expand capacity significantly in a short time span.

Not only is the U.S. textile machinery industry more fragmented than in past emergencies, it does not have the complete machinery product lines to furnish the textile industry. Much of the special purpose machinery used in military fabric and yarn production is no longer available from the industry.

Repair parts to sustain the large volume of foreign textile machinery now operational in the U.S. textile industry cannot be procured from American textile machinery producers. The current practice of U.S. textile firms of maintaining four to six week inventory of repair parts would mean significant reduction in output after this inventory was consumed if supply lines from Europe and Japan were disrupted.

The role of the U.S. textile machinery industry in all prior emergencies was to produce the key textile capital equipment required for defense work, adapt existing equipment for defense fabric production, and to assure textile producers of a continuous flow of repair parts for existing equipment. Despite this vital role, this left a significant capacity for precision metal forming that was utilized by the government for munitions, weaponry, sub-contracting, and manufacture of essential capital machinery for defense purposes.

Demands of the textile industry in a future emergency would require concentration on their requirements by the textile machinery industry and exclude the possibility of augmenting defense efforts in other fields. Even with this concentration on U.S. textile requirements, the time required to design, tool up, and produce non-consumer oriented textile machinery for military purposes would require a minimum of 18 to 24 months to have a significant productive impact. [18]

---

18 — The above statement with respect to textile machinery has been checked with responsible representatives of the U.S. textile machinery industry and represents a consensus view of the situation that would exist in a future mobilization effort.

V. MATERIALS

Textile Fibers

The principal fibers used in military textiles at this time are cotton, wool, and nylon, with polyester used in a limited way in blends. Minor amounts of other man-made fibers are used for special purposes, including some new fibers which are just becoming available.

In general, the principal fiber properties which are considered to be of greatest importance in the selection of a fiber to meet the technical requirements of military textiles listed in Appendix A are as follows:

Cotton

- Moisture absorption
- Ability to react with permanent water repellent and other chemical treatments
- Fiber swelling
- Increased strength when wet
- Comfort
- Low cost

Nylon

- High strength/weight ratio
- High energy absorption
- Elastic recovery properties
- Abrasion resistance
- Fiber rupture elongation

High Temperature Resistant Polyamide (NOMEX)

- Resistance to flaming
- Self-extinguishing

Wool meets the essential technical requirements for uniform fabrics and is superior in many respects to other fibers for military uniforms although it is being increasingly blended with other fibers to attain certain balance of fabric properties.

A blend of polyester with wool (55/45) is currently used in the tropical fabric for the Army summer service uniform; a blend of polyester with cotton is currently in the process of being adopted for a durable press, short-sleeve shirt/trouser semi-dress summer uniform.

Other fibers currently being used or under evaluation include a high temperature resistant polyamide (NOMEX) in aviators' and tankers' clothing to provide protection against crash and flash fires; polypropylene in twine and, experimentally, Dynel in tentage fabric. A new ultra-high strength aromatic polyamide fiber is also being evaluated for personnel armor.

While possibly a new fiber could be developed during the next decade and come into commercial production, the normal time cycle from development through pilot plant production to large scale production is such that it is unlikely that any new fiber not presently on the market would become of significant volume importance from a military standpoint within the next decade to alter the dependence of the military upon existing fibers within the time frame of this study. Modifications of existing fibers, however, could occur, together with methods of forming them into fabrics which could lead to changes in present usage. Also, there is a great deal of basic technical and scientific information and military service experience available on existing fibers which would need to be similarly obtained on any new fiber before its adequacy and adaptability to all military requirements could be assured.

Accordingly, in looking at future military requirements in the 1980-85 time frame, the projection should be based upon existing fibers, their technology and their potential supply, and in the case of the non-cellulosic man-made fibers, the potential availability of feedstocks from the petrochemical industry. This, in turn, necessitates consideration of the general U.S. energy outlook; the increasing dependence of the country upon imported oil and gas and the potential deficit in the balance of trade in the 1980-85 time frame resulting therefrom.

Figure 13 shows one projection into the 1980's of the growth in domestic consumption of textile fibers (mill consumption plus imports less exports) as reported in "Textile Organon", Textile Economics Bureau, Inc. The estimate, which comes from a responsible industry source, indicates that domestic consumption will expand from 12.3 billion pounds in 1972 to around 15 billion pounds by 1978, and 18 billion pounds by 1983. This reflects a constant growth rate of around 3.5% per year which indicates a significant increase in per capita consumption in addition to the projection for population growth.

Where this growth in fiber consumption is most likely to occur is indicated in Figure 14. From that it will be evident that the major growth occurring at this time is in the non-cellulosic man-made fibers, and according to all present estimates, it is in these fibers that the major increase in fiber consumption will occur. Consumption of rayon and acetate is showing no growth and consumption of both cotton and wool is in a down-trend. There is every reason to anticipate at this time that these basic trends will continue during the next decade.

One of the most significant factors favoring continued expansion in the consumption of the man-made non-cellulosic fibers is the fact that polyester staple fiber is now in a competitive price area with cotton. Figure 15 shows the current price relationship between polyester staple, viscose staple rayon and cotton. [19]

Actually, at the same price, cotton costs more than polyester or rayon staple since it takes two or three cents per pound to move cotton from the spot markets to the mill. Also, there is the factor of waste in opening and carding. On this basis, branded polyester costs

---

19 — Prices shown are from the National Cotton Council of America, and represent prices actually paid by mills rather than quoted list prices.

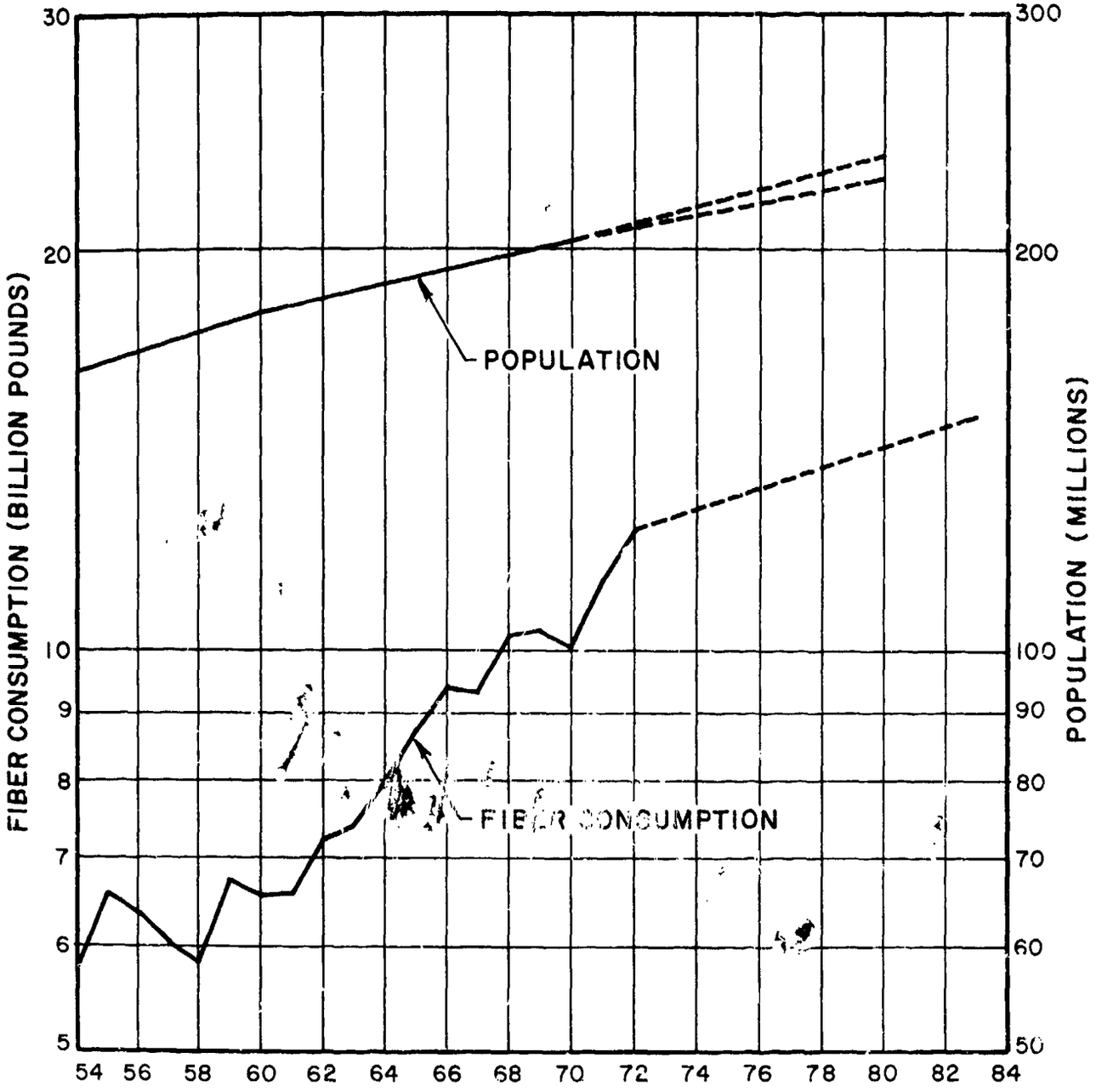


FIGURE 13 DOMESTIC CONSUMPTION OF FIBERS AND POPULATION PROJECTIONS

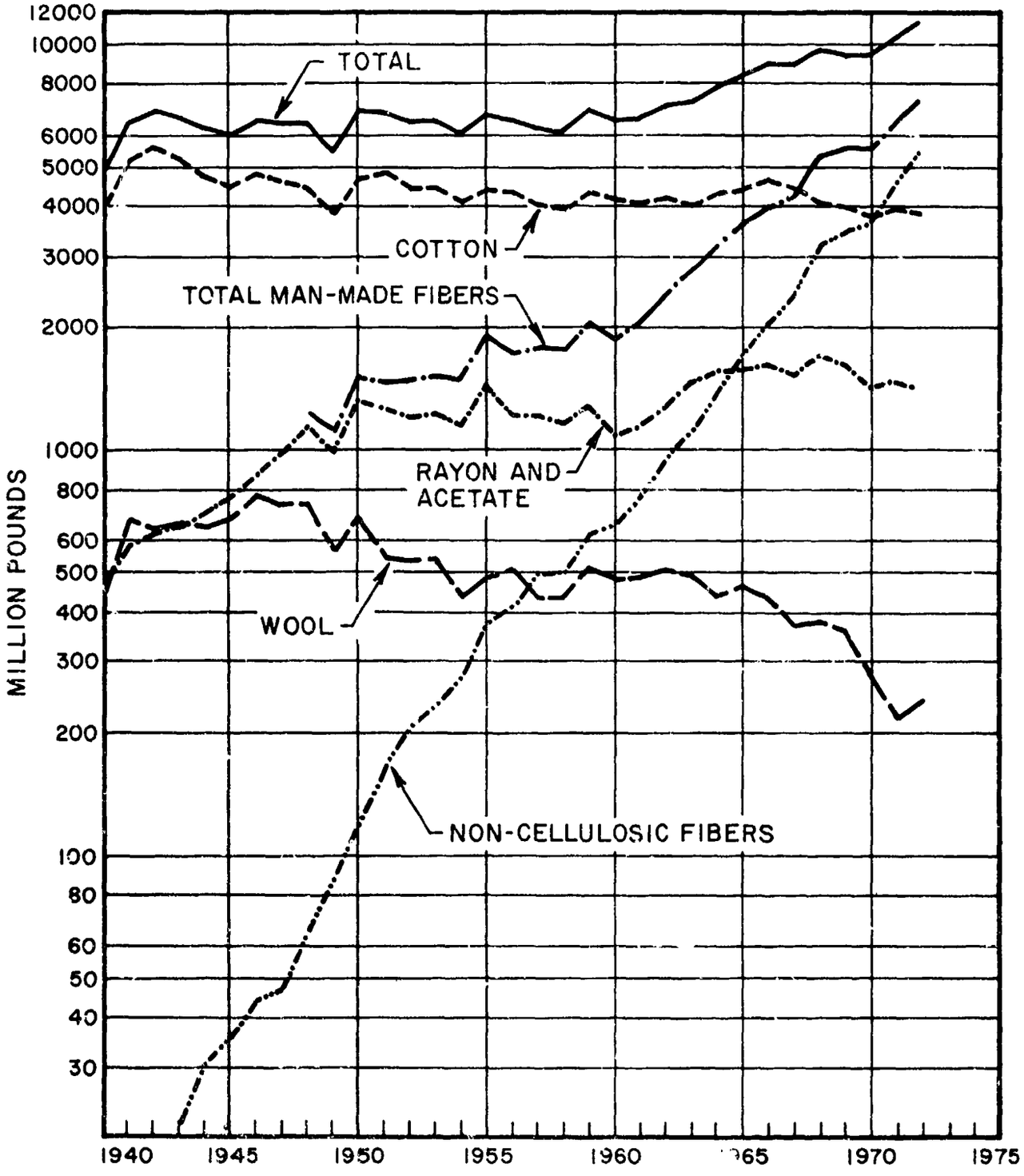


FIGURE 14 U.S. MILL CONSUMPTION
(SOURCE: TEXTILE ECONOMICS BUREAU, "TEXTILE ORGANON")

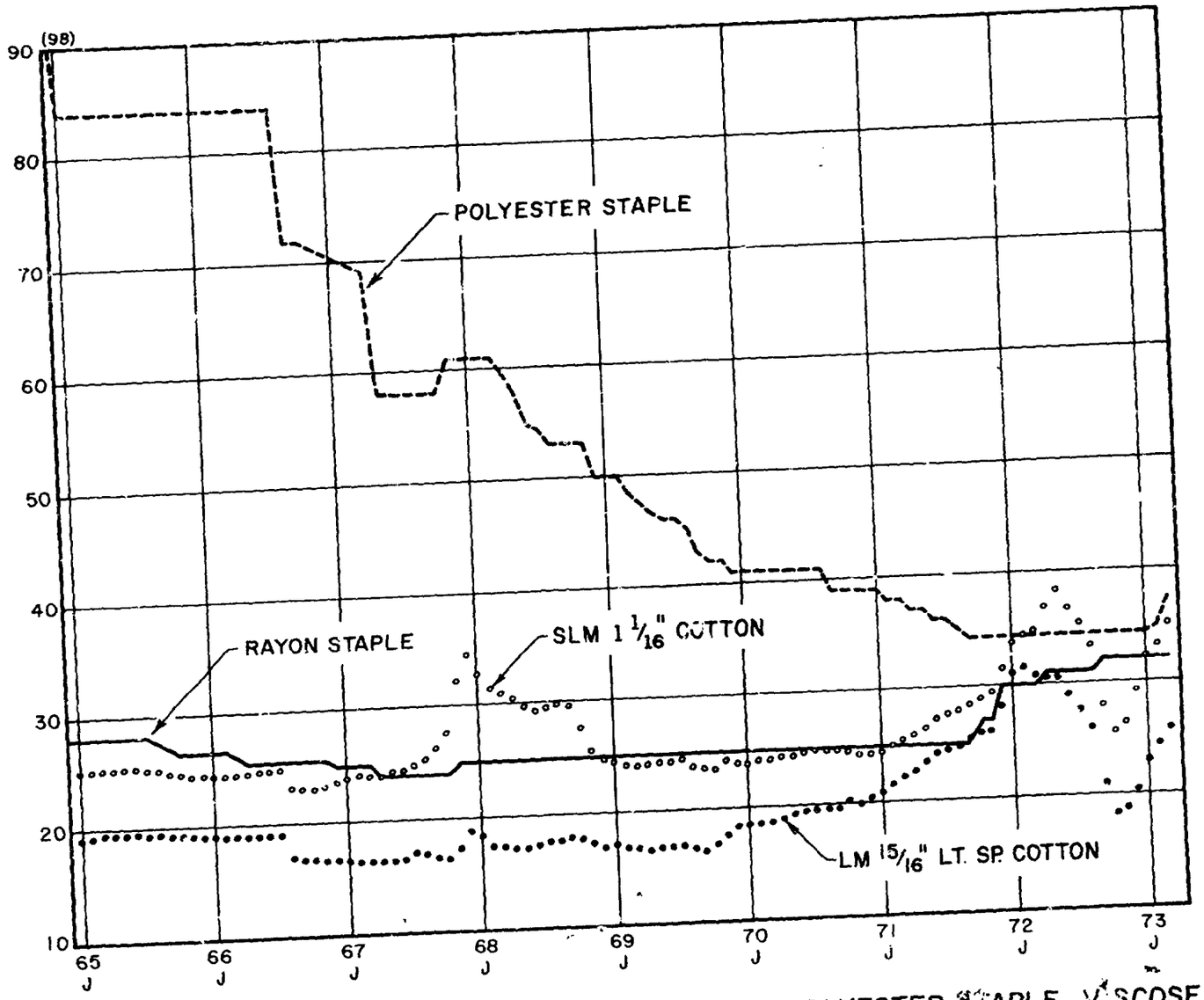


FIGURE 15 COMPARATIVE PRICES : COTTON, POLYESTER STAPLE, VISCOSE STAPLE (1965-1973)

less in yarn form than many of the better qualities of cotton. Accordingly, polyester staple has now become cotton's principal competitor, and a mill may be able to lower its price by moving out of 100% cotton into a polyester blend where the quality and acceptance of the product will permit it. In addition, polyester has the advantage of not being subject to the violent price swings of cotton; mills do not have to contract far ahead to guarantee their supply, and the quality and total supply is not subject to the weather.

On the other hand there are advantages to cotton. Durable press, for example, requires the presence of a cellulosic fiber in the fabric to react with the chemical treatment of the durable press process (although all-polyester durable press fabrics have been produced). Also, cotton has comfort qualities stemming from its moisture absorption characteristics — something lacking in the non-cellulosic, man-made fibers presently available.

However, since for the most part, fiber blend yarns of polyester and cotton can be spun on the same equipment as all-cotton, and the same weaving equipment can be used, the transition from all-cotton to polyester/cotton blends is not a difficult one. From this standpoint, the trend toward polyester/cotton blends, where the blended fabric can substitute in military uses for all-cotton, does not present any significant problem from the standpoint of mobilization planning.

A problem of greater importance is what to do about the decline and dissolution of a woolen and worsted industry of significant size, and what fabrics to plan for as replacements for all-wool fabrics in uniforms.

Whether suitable plain color uniform fabrics conforming to the essential technical requirements outlined in Appendix A can be produced from knit polyester texturized filament yarns, especially with the long-wearing and appearance qualities essential to a military uniform, remains at this time to be determined. Knowledgeable people are of the opinion that a blend of polyester staple and wool in combination with some texturized filament will provide a suitable substitute military uniform fabric. The testing and verification of the suitability of such fabrics still lies ahead at this writing.

Also, there is the possibility that the technology of stretch-woven fabrics, again using texturized polyester filament yarns, will provide a means for developing alternate fabrics. Success with this type of fabric could reduce or eliminate the need for spinning, and especially would not require the use of woolen and worsted spun yarn.

In stressing the need to develop alternate fabrics to present wool uniform fabrics, it is not intended to advocate the dropping of wool fabrics for military uniforms at this time. However, looking ahead to the 1980-85 time frame, and considering the national policy with respect to imports, it would be totally unrealistic to assume that new investment will come into the moribund woolen and worsted industry to rebuild its capacity. Some limited capacity

undoubtedly will survive, but it is more likely that our import policy will have resulted in practically total liquidation of this industry during the next decade. Where wool will continue to be used will be in limited amounts in blends to impart to them some of the unique and excellent properties of the wool fiber.

So far as duck for tentage is concerned, all that can be said at this time is that an aggressive, well-funded program to produce a substitute material for all-cotton, fire resistant duck should be undertaken on an urgent priority. The search should be for a fabric which could be made on a broad basis in a large segment of the industry — not something requiring a complicated technology — but a fabric which could go quickly into production by the tens of millions of yards. Possibly the search for fire resistant civilian fibers and fabrics will hold the key to the development of a substitute for cotton duck for tentage.

From a fiber standpoint, in summary, the military are confronted with the fact of a decline in the production of all-cotton textiles, the rapid growth of the man-made non-cellulosic fibers, particularly polyester (both in staple form and in texturized filament yarns), the loss of an adequate production base in wool textiles, and the absolute need for the development of substitutes for cotton duck. All of these fiber factors place an urgent requirement upon the military and the textile industry for an adequate research and development program to develop, test, and adopt alternate materials which will be consonant with the fiber and textile manufacturing capacity situations as they may exist in the 1980-85 time frame. Development of alternate materials meeting the critical and essential technical requirements of military textiles and having an assured broad base of supply may well take that long.

Man-Made Fibers

While in a short range estimate it would appear desirable for the Department of the Army and the Department of Defense to move toward broader use of man-made fibers in military textiles, from the standpoint of the 1980-85 time frame there are distinct hazards to placing too great dependence upon textile fibers produced from feedstocks from the petrochemical industry.

The assessment of the energy outlook for the 1985 time frame made by the Committee on the U. S. Energy Outlook of the National Petroleum Council, and published in December 1972 by the U.S. Department of the Interior, has placed the entire situation with respect to supplies of petroleum and gas in a context which necessitates differentiating between uses for man-made fibers where they are required to meet critical or essential military characteristics, from uses where natural fibers or blends would equally serve military needs.

Of the three options for balancing energy supply and demand beyond 1975 outlined in this report: (a) increased emphasis on development of domestic supplies; (b) much greater reliance upon imports from foreign sources; and (c) restraints upon demand growth, the report endorses (a) as the best option, while indicating that all three may be needed to contribute to solving the nation's energy problem. [20]

Of the data presented by this Advisory Committee to the U.S. Department of the Interior with respect to the total energy problem, the following Table, reproduced from the report is perhaps most significant in indicating the seriousness of the supply situation on petroleum products to be anticipated in the 1985 time frame.

TABLE XVII

Balance of Trade Deficit in Energy Fuels —1985

(Billion Dollars)

	Initial Appraisal	Case I	Case II	Case III	Case IV
Oil Imports (Delivered)	22.4	5.4	13.1	20.4	29.1
Natural Gas & LNG Imports	5.5	4.9	5.0	5.3	5.4
Total Energy Fuel Imports	27.9	10.3	18.1	25.7	34.5
Oil Exports	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)
Steam Coal Exports	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)
Metallurgical Coal Exports	(2.1)	(2.1)	(2.1)	(2.1)	(2.1)
Total Energy Fuel Exports	(2.8)	(2.8)	(2.8)	(2.8)	(2.8)
Total Energy Fuel Deficit	25.1	7.5	15.3	22.9	31.7

Source: U.S. Energy Outlook, pg. 298.

20 — National Petroleum Council's Committee on U.S. Energy Outlook, "U.S. Energy Outlook" U.S. Dept. of the Interior. 1972. pg. 3.

The four cases cited represent different assumptions as to action that may be taken during the next decade to aggressively develop domestic fuel sources: Case I assumes the most optimistic courses of action without any restrictions as to environmental problems, economics, etc.; and Case IV that current trends in dealing with the situation will continue. Cases II and III are intermediate. The Initial Appraisal projections were regarded in the final report as perhaps more optimistic than were justified. [21]

The seriousness of the trade deficit under any of these situations, even the intermediate Cases, would present national problems of the gravest significance, particularly since the needed supplies of oil would have to come very largely from the Arab countries of the Middle East. In some of the Cases, shown in Table XVII, as much as three-fourths of U.S. oil imports in 1985 would have to come from the Eastern Hemisphere compared with 16% in 1970. The three-fold to fifteen-fold increase in foreign exchange requirements in 1985 above the current level could not be easily offset. This overall situation could have serious consequences upon the military, political, and economic security of the United States, since our country would become increasingly dependent on the political and economic policies of a relatively small number of countries. [22]

Certainly, if the United States were to become dependent to the extent indicated upon imports, largely from the Middle East, which is an area of potential conflict, the energy supply situation in the United States during an outbreak of hostilities would necessitate restrictions of major proportions upon the use of petroleum products, which undoubtedly would have to include reductions in allocations to the petrochemical industry and products based upon its output. Those who went through World War II will recall the extreme restrictions upon the use of rubber, the rationing of gasoline, the modifications made in clothing to save cloth, and even the reduction in the size and number of pins used to pin a shirt for packing.

With the hazard of a reduction in the supply of petroleum products of the magnitude indicated by what appears will be our dependence upon imports during the time frame being used for this study, it would be totally unrealistic not to assume that drastic limitations would have to be placed upon the production of textile fibers drawn from these sources. The supply of man-made fibers for critical and essential military uses can be expected to be assured, but for uses where other fibers could serve reasonably well or which have been used in the past, it is not to be expected that priorities could be justified.

It must be recognized that the actual situation with respect to availability of energy from domestic sources as it may exist during the time frame projected for this study will depend, quite obviously, upon the urgency with which increasing domestic energy supplies is attacked.

---

21 — Ibid , pg. 1
22 — Ibid , pg. 8

Considering on the one hand that the U.S. Energy Outlook report places its greatest emphasis for solution of the energy problem upon increasing nuclear power output [23] while simultaneously environmental reviews — as many as 60 clearances from local, state and national agencies may be needed — are delaying the planned operating dates of most of the nuclear plants that have been announced, it does not seem likely that this source will be contributing as much to the energy mix by 1985 as an optimistic forecast would hope for.

Whether within this time frame the necessary political, economic and financial actions could be taken to adequately increase supplies of energy from domestic sources to hold down our growing dependence upon foreign oil and gas to limits which could be considered safe from a national defense standpoint, can not be forecast at this time. Considering the extent to which such developments would have to depend upon political actions, it would be unwise to assume that dependence upon foreign oil imports will not come close to the higher levels that have been indicated. If these supplies were to be cut off in the event of a sudden outbreak of war, the domestic energy problem would unquestionably require drastic curtailments of every kind in the use of oil and gas and products derived from them.

Since this analysis is concerned primarily with the capability of the textile industry to provide support to a sudden military mobilization, it would appear prudent to emphasize the need for being prepared for the use of alternate textile fibers, the supply of which would not be dependent upon oil or gas, and which would require the minimum amount of energy for their conversion into military textiles. This would indicate the desirability for the military services to be able, in such an emergency, to obtain quickly large quantities of military textiles made in large part, at least, from cotton and wool.

The prospect of a situation in which imports of both imported textiles and imported oil and liquified natural gas (LNG) by a sea blockade would be serious enough today, but in the projected 1980-85 time frame, it raises a specter of internal civilian shortages of a magnitude never before visualized by the textile industry or the American public. To prepare against such a contingency the military authorities should give careful weight to assuring the availability as an alternate of adequate supplies of the natural fibers and an industry capability for converting them into textiles.

---

23 — Ibid. pg. 201.

Cotton

The policy of the military services with respect to the use of cotton in military textiles was summed up in July 1966 in a statement as follows:

> "In view of the fact that it is the U.S. Government policy to support cotton, it is considered that the Defense Department should utilize cotton wherever practicable in military textile items.
>
> "For some uses the properties of cotton make it the preferred fiber. For other uses the properties of other fibers make them more desirable than cotton. Basically, the Department of the Army utilizes cotton as a fiber in textile materials except where:
>
> "a. There is a distinct advantage from a functional standpoint in the use of some other fiber, e.g., significant lighter weight, greater strength, superior properties in respect to flame, thermal resistance, mildew resistance, etc.
>
> "b. Other fibers are available at lower cost in a product of comparable functional properties.
>
> "c. Where, due to limited industry capacity, cotton textile materials can not be made available in adequate quantity to meet the delivery schedules of the Government procurement agency." [24]

The assumption that cotton would always be the ultimate, low-cost textile fiber has now been challenged as indicated in Figure 15, by the fact that today both polyester and viscose rayon staple fibers are being priced in the same price range as the better grades of cotton. Also, while higher raw material costs may force the prices of man-made fibers upward, the price of cotton is also likely to rise as a result of general inflation and rising costs of producing cotton. Today, the preference for cotton fabrics for military textiles on the basis of lower cost does not hold for all items. Blended fiber fabrics are available for some uses at no greater cost, and have greater durability.

Sheets are an example of a product where the military services have adopted the polyester/cotton blended materials in place of all cotton. Adoption of the blended sheets in 1971 was based on two factors: the industry had already shifted over to the blend, and it was no longer possible to obtain all-cotton sheets in the quantities and for the deliveries required by the military. More important, tests had demonstrated that the blend would out-wear the all-cotton item by about two to one.[25]

Replacements of cotton have also been made where distinctly superior performance can be obtained from man-made fibers. The case of load-carrying equipment has been noted above. On the basis of current trends within the textile industry to shift further to man-made fibers, and also because of price competition between polyester and cotton, it may be expected that in the near future, further shifts to the use of man-made fibers

---

24 — US Army Natick Laboratories, "Policy on Use of Cotton in Military Textile Items," Natick, Mass. July 1966.

25 — US Army Natick Laboratories, "Engineering Practice Study of Sheet, Bed and Pillowcase, Cotton and Polyester/Cotton" Proj. No. 7210-0144. Natick, Mass. Apr. 27, 1972.

will occur in military textiles. As was the case with sheets, the military cannot continue to seek to use all-cotton materials if the industry is not making them for the civilian market.

What is called for here is a national policy with respect to the overall energy outlook. Such a policy seems to be emerging in the growing realization that the best means for bringing our foreign trade into balance is to capitalize upon the potential of American agriculture to produce for export vast quantities of food and fiber products which the rest of the world needs. We have the acreage, the climate and the knowledge of how to produce abundant crops, and with it, the ability to create a surplus for export over and above our own needs.

While we have used up during the past century so large a proportion of our exhaustible resources, we have one resource, that if properly cared for never becomes exhausted — our farmland. During the past two decades we have lost to a large extent, for many reasons, our edge over Western Europe and Japan in manufacturing efficiency and technology. Even after the deflations in the dollar which have occurred up to this time, our labor costs are still high in relation to much of our competition. But we can produce agricultural products more efficiently than anyone else in the world.

Until such time as a national policy emerges with respect to the energy outlook, or there is a new look at the role of agricultural products, including cotton, with respect to our trade balance, it must be expected that the role of cotton in the textile industry will continue to decline in competition with the man-made fibers. If this occurs, as appears likely, it will be to the disadvantage of the military services from the standpoint of their ability to be supported in textiles in the event of a major mobilization. It is doubtful, however, if any action by the military services alone, attempting to deal with some possible future undefined need, will have much effect upon this trend.

It would be useful, however, to point out some actions with respect to cotton which it would be desirable to take, and which the military services should support in order to keep this option a viable one for their future protection. Among these, perhaps the most important would be the following:

— The continuance of adequate incentives to assure the production of a large enough crop which could keep the United States as an important factor in the cotton export market. With a continuing surplus above domestic consumption of cotton and ability to price it competitively, there would be a reserve both of fiber and acreage which would be available for increased production in the event of a mobilization.

— Appropriate steps to increase the carry-over so that a balanced stock of grades and staples would be available in a future emergency. As shown in Figure 16, the carry-over has[26] now declined to a level where it would not be adequate from a military standpoint if a need arose for a sudden increase in production of military fabrics. Just what a suitable carry-over level should be is something that should be the subject of an appropriate study. It would appear, however, on the basis of the experience during World War II and the Korean War,

---

26 - National Cotton Council of America.

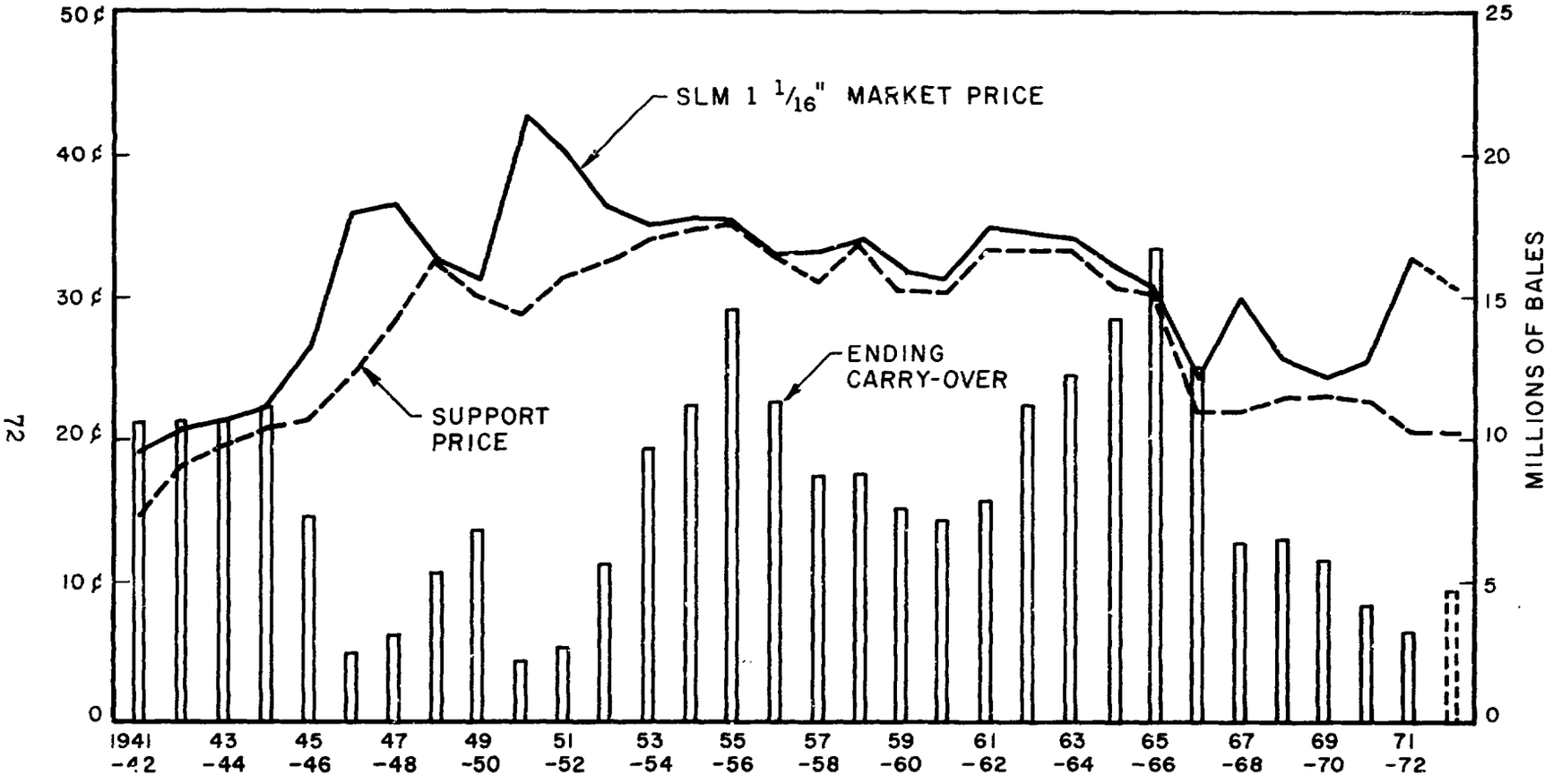


FIGURE 16 COTTON PRICES AND CARRY-OVER

that it should approach one year's crop. The unfortunate reduction in acreage in the Spring of 1950, just before the outbreak of the Korean War should serve as an object lesson that reserves of a basic military raw material should be kept at an adequate level, particularly where they do not become a static stockpile.

— Any possible actions which would tend to stabilize the price of cotton, and thereby make it a more desirable fiber for use by the textile industry. Wide gyrations in the price, such as have occurred several times in recent years, have hurt the market for cotton and weakened its competitive position.

In summary, it must be recognized that a major military policy must always be to plan to utilize materials which are readily available in adequate amounts from domestic sources, and to avoid being dependent upon materials which must be imported, and the supply of which, in time of war, could be subject to being cut off through blockading of the sea lanes. Taking into account the cloud on the horizon with respect to the unavoidable increasing dependence of the United States upon imports of oil from the Middle East over the next decade, it should become a matter of basic policy for the military services to provide practicable assistance to maintaining a viable cotton textile industry and adequate supplies of raw cotton.

VI. LABOR

Industrial mobilization of the textile industry in support of a rapid expansion of the armed forces would necessitate an adequate labor force to assure full utilization of industry capacity. It does not appear at this time, however, that there can be assurance that the textile industry, which has become increasingly concentrated in a relatively small area in the Southeast, could count on a labor supply that could assure full-scale operation.

Currently, a critical labor shortage exists in the textile areas of the Carolinas. It does not appear there is any reasonable hope that this situation will be alleviated in the foreseeable future. Unemployment has recently been reported as low as 1.4% in the Greenville area, and mill managements regard their future labor supply as a critical problem.

In March 1973, the announcement that the Michelin Tire Corporation was planning to build two plants in Anderson and Greenville counties, South Carolina, was met by opposition by the press of the State. A Columbia, South Carolina paper stated that "serious economic dislocation can result from the sudden creation of a large demand for labor in a tight labor market. The victims can be not only the textile industry but later industries which themselves have become integrated in the local economy. They, too, must have a labor supply to continue in business." The two plants would require an estimated 1800 workers by 1974-75. Textile and other industries in the area were deeply concerned. [27]

This tight labor market in the textile manufacturing area represents the impact of the big southern drive during the 50's to bring industries into local communities in the South where labor was available and unions relatively ineffective. As a result, the area from Richmond, Virginia to Montgomery, Alabama became the fastest growing industrial area in the country. In an article in the Daily News Record of November 30, 1972, it was stated that few mills in the Southeast were able to man three six-day shifts to meet the upsurge in demand for cloth.

In a competitive labor market, textiles are at a disadvantage for a number of reasons. Among these the following are most frequently cited:

— Young people are not being attracted to the mills, and the average age of workers is rising.

— Textile mill production is geared to three shift operation, and in a tight labor market, it becomes difficult to man the second and third shifts.

— Increasing the labor supply in the textile areas would necessitate bringing in workers from the outside. This would require long range planning, housing developments, training programs, and the risk of losing such labor to competing industries.

— Wage rates in textile mills have been lower than in competing industries. The pressure of competition from imports from low-wage countries, where labor is paid only a fraction of the U.S. wage, holds down wages in the textile industry. Local differentials

27 — Daily News Record, New York. March 12, 1973.

may not be large, but competing industries are better able to pay a higher wage and to maintain a differential. Overall average hourly gross earnings for textile mill employees in January 1973, as reported by the U.S. Bureau of Labor Statistics, were $2.86 as compared with $3.99 for all manufacturing industries. This wage differential militates against bringing in labor from the outside.

It is generally conceded that if new mills were to be built, they would probably be located outside the present textile manufacturing areas. However, as indicated above, the likelihood of any large scale expansion of the textile industry, particularly in the broad-woven goods manufacturing industry, is quite unlikely in the immediate future.

While more could be said about this labor situation, it is considered that what has been outlined above is indicative that a decade hence there could well not be the available labor supply to obtain full-scale production from the textile mills. Certainly, if men were called into military service, taking labor out of these areas, the difficulty of obtaining full production could create a serious problem for the military during the critical early period of mobilization.

VII. OTHER RELATED INDUSTRIES

While the major concern of this study has been focused upon textiles, and primarily broadwoven goods, the fact that textiles must be finished and then fabricated into various end products for military use necessitates that some consideration be given to potentially critical supply and production areas in their finishing and fabrication.

Dyes

The fabrics for military uniforms, clothing and equipment are produced in a relatively few shades which, for the most part, do not conform to volume shades produced for the civilian market. Also, field items are colored to provide camouflage against both visual observation and detection by various types of battlefield surveillance instrumentation. Hence, in large scale military procurement of textiles, large quantities of particular dyes would be needed. In general, this could be achieved without major problems in industry conversion, due to the general versatility of dyestuff manufacturing capacity. The chief problem would be one of the time required for conversion. Also, since these requirements would be met by sub-contracts, integration of dyestuff requirements with cloth procurements would be needed to avoid potential delays in finished textile deliveries.

The environmental problem caused by the use of mercuric oxide in the process of making alpha-amino anthraquinone, has led to the discontinuance of the U.S. manufacture of this key intermediate for the vat dyes used in military shades. While potentially this problem may be resolved over the next decade, the fact that it exists and could be a source of delay in meeting military requirements should not be overlooked in mobilization planning.

Clothing Manufacturing

Since items of uniform and clothing used by the military services utilize the same technology and equipment as corresponding civilian items, it may be assumed that adequate sewing capacity would exist in the civilian garment industry to meet military requirements in a mobilization.

Such an assumption should be made with considerable caution. The clothing industry is comprised for the most part of many relatively small firms geared to specialized production of particular items, and the mobilizing of sufficient capacity for major build-up in Vietnam in 1966, which was of relatively small size, made it necessary to issue rated orders on clothing and uniform manufacturers in order to get enough production to supply our troops.

Also the assumption that garment manufacturers can turn readily from a normal civilian line to making a military item is not actually true. The transformation of a sewing room by rearranging the production line, re-training of workers, establishing new quality controls, etc., is not something that can be done without time being required for this change-over to be made.

Military items furthermore are not necessarily similar to civilian items which a particular firm may be making. For example, the combat coat and trousers of the Army are provided with special functional features: cargo pockets, closures at the wrists, etc., an action sleeve and a hood that drops down inside the collar, and utilize cloth and findings that may be quite different from what the firm may have used in its own lines. Also, special sewing machines may be required to perform certain operations that could be foreign to the firm's normal production.

Experience has shown that conversion of garment manufacturing plants takes much more time and is far more complicated than is assumed by military planners who are not familiar with the operations of the garment industry. The extent to which conversion may have to extend in order to get needed production may be indicated by the fact that in World War II, women's girdle manufacturers were converted to making men's shirts and trousers. Obviously, much new sewing equipment was needed, and new training before such plants could get into production.

Also, with the wide range of quality which exists in civilian products, the attempt to get a large number of firms all producing a given item to the same quality standards creates problems in conversion: the better grade houses have to change their normal manufacturing procedures and may drop certain operations, such as use of hand finishing, while lower grade firms may have difficulty getting their quality up to a minimum standard. This observation remains valid even after making allowances for variation in quality which may have to be accepted from different firms.

The major problem here is not that conversion cannot be accomplished. It is that time is required -- and avoidance of delays during the critical first year of mobilization must, in every possible way, be the major concern of those involved in planning and procurement.

Equipage and Tents

The canvas goods industry, which is the base industry for the production of military equipage and tents, is comprised for the most part of relatively small firms specializing in serving a local market. The expansion of production required in time of mobilization far exceeds the capacity of the industry, and many new firms must be brought into production, if quantity output is to be attained quickly.

The comments made earlier in this study with respect to cotton duck are, in general, applicable here. Building up to large scale production of packs and the other items of

personal equipment of the soldier, sleeping bags, paulins and tents — particularly large tents — all will present a major problem. Since these items, unlike basic clothing items, do not wear out in peace-time use, stocks on hand serve for a long time. As a result, there is little peace-time procurement, and few firms are geared up to go into production when requirements do arise. In a sense, this problem simply increases the problem already outlined with respect to duck, except that where substitutes for duck are developed, the fabrication problem will still need to be solved.

Personnel Armor

Just what form personnel armor will take a decade hence cannot be forecast at this time. However, to the extent that textile materials are used, there will be the dual problem of fabric production and item fabrication. Again, these are items that do not wear out in peace-time, so that it would be unlikely that there would be firms in production for the military at the time of mobilization.

There is the further important problem of the helmet and liner. Currently, the helmet liner is a nylon reinforced plastic molded item. Considerable difficulty was encountered getting new firms into production of it during the war in Vietnam, and serious delays were encountered. This, again, is not a peace-time industry, and production would have to be started from scratch to obtain large production. Whether it is just the liner or the entire helmet that would require molding, the problem of getting into volume production could present major problems.

Parachutes

Just what role parachute delivery of supplies and personnel will play in combat a decade hence cannot, of course, be forecast at this time. It would be unreasonable to expect, however, that some air delivery, at least of supplies, would not be required, so that planning for the manufacture of parachutes should not be overlooked.

Parachutes are an item, however, which has no significant civilian counterpart. Parachute manufacturing is basically a war industry, and without a continuing procurement program, it would have to be expected that production would have to start at first only from a limited industry base in the event of mobilization. Of the nine firms currently in this industry,[28] it would be doubtful that more than one or two could survive a prolonged period of peace with little military procurement.

Coordinate with the parachute textile materials, there is the specialized hardware used in the parachute. Whether the tools and dies needed for production of these components would be available after a long period of low procurement presents another problem.

---

28 — Defense Supply Agency, "Report on the Management of Parachutes (FSC 1670) within the Department of Defense." March 1966.

While the need for aerial delivery may be unpredictable, experience has shown that where air delivery of supplies is needed, very large numbers of parachutes are needed, and that these may be largely expendable — recovery may be so low that the quantity of parachutes required could reach very large proportions. The need for an expendable parachute, which could be produced very quickly in very large quantities could well be one of the most critical items required in some future emergency. It would appear that the provision of an adequate production base for such an item could well be the determining factor in the success or failure of a military operation or the ability of a military force to be able to continue to be effective. The importance of mobilization planning for such a contingency cannot be over-estimated.

Other Related Industries

As is well understood by the industry groups that would need to be called upon to meet a military emergency, there are many other industries which must be able to provide support to the major textile manufacturing, finishing and fabricating industries directly concerned with supply to the military establishment.

It is not necessary to dwell here on this aspect in depth. On the other hand, it has been noted that military officers who do not have background in the textile and clothing commodity areas find the complexity of production and supply in these fields baffling and frustrating. The provision of commodity training to military officers who will have responsibility for planning and procurement in this area is essential to their effective understanding of the operations and the inter-relations of these various industries, especially where a major effort must be made to move into volume production quickly on military textile items.

VIII. SUMMARY AND CONCLUSIONS

The basic question for consideration in this study has been whether the textile industry, as it is now constituted and with the trends presently taking place within it, could, in a future mobilization, meet the needs for military textiles.

This question actually has two parts: first, would there be a broad industry base to supply the needed military textiles by immediate conversion of the industry on a broad scale to provide large quantities of textiles quickly; second, if the conflict were prolonged, would the industry base be adequate to meet the needs of both the military and the civilian population?

That a critical supply problem could occur in textiles has not been seriously considered by the military services in the past. Generally, it has been assumed that in an area like textiles, where the military product resembles the kinds of products the industry makes for civilians in time of peace, industrial capacity could be quickly turned around in time of war to producing what the military would need.

The performance of the textile industry in meeting military requirements in World War II, the Korean War and our involvement in Southeast Asia has contributed to this attitude. However, the unusual circumstances and the extraordinary efforts which made it possible for the textile industry to supply the military with its requirements during these mobilization periods, particularly during the rapid build-up in World War II and Korea, are no longer remembered.

As a matter of fact, the textile industry as it existed in these three war periods of the past thirty years no longer exists. The circumstances which made possible the successful supply support of textiles and products made from them could not be re-created even today.

Also, the production base of this industry is no longer relatively static, i.e., that a mill having certain equipment and making a certain type of product can be assumed to be making essentially that same type of product at some future date. To keep abreast of changes in the market, mills making one product this year may be converted a year or two from now to making a wholly different product using quite different production equipment.

Accordingly, both the military services and the textile industry have a whole new set of factors to deal with in respect to mobilization of the production capacity of the textile industry for military production, and over the next ten to fifteen years, far greater changes must be expected to take place.

Military Requirements

To deal with the basic question underlying this study, it has been necessary to define military requirements in some specific terms.

According to their technical requirements, military textiles can be considered as falling into two major groups: those for which specific functional performance characteristics are critical or essential, and those which conform closely to their commercial counterparts. The technical requirements for the first group have been carefully reviewed and are stated in Appendix A. It will be noted that the technical requirements for these military textiles are relatively inflexible. In large part they relate to the protection, safety and efficiency of combat troops and can be met only by specific types of textiles for which an adequate industry production base, capable of rapid expansion in a mobilization, is essential to the effectiveness of our military posture.

Quantitative requirements present a different kind of problem, in that whatever the requirements might be would be dependent upon a highly complex array of unknown future events and assumptions with respect to them which are beyond the scope of this study. What has been done, however, has been to review quite carefully the experience of the textile industry with respect to the mobilization efforts in the three wars in which our country has been involved during the past thirty years. From this analysis, an assumption has been made , to give this study some base of reference, that, as occurred in both World War II and Korea, in a future emergency in the 1980-85 time frame our armed forces would have to be doubled in strength during the first year. The situation with respect to Vietnam, involving a creeping mobilization, has not been considered as typical of what might occur in some future mobilization.

Taking into consideration the above, and also the important statement made by General Eisenhower in his Final Report as Chief of Staff in 1948, that "What we are able or not able to do within the first sixty days of another war will be decisive in its determination of our ability to carry the war to a successful conclusion" [29], the study has been focused upon the speed with which the industry could respond to a call for immediate production of large quantities of military textiles within the shortest possible period of time.

The review of our experience in World War II shows that the textile industry was able to meet the requirements for textiles to support the mobilization of our armed forces, only because of the partial mobilization which had already been occurring during the preceding two years through the existence of unused production capacity and ample stocks of raw materials, and mandatory controls by which many complex conversions of capacity to military use could be accomplished.

---

29 — Dwight D. Eisenhower, Final Report of the Chief of Staff, United States Army, to the Secretary of the Army, February 7, 1948. pg. 17.

The Korean War, if it may be considered as representative of the situation created by a sudden outbreak of hostilities, showed the dimensions of the problem of industrial mobilization as it applied to the textile and related industries. Here, delivery of critical items of supply could not be effected until the second year of the war. Without carry-over stocks from World War II, the supply failure would have been little short of disastrous. As it was, it became necessary in January 1951 to stop induction of troops into the armed forces due to shortages of clothing and uniforms. The circumstances which contributed to these supply problems could well be repeated in some form in any sudden call for mobilization.

Trends in Industry Capacity

Almost all military textiles fall into the broadwoven goods sector of the industry. While total production in the area amounts to around 11 billion linear yards per year, military textiles are concentrated in a relatively few classes of products as shown in Table XII, page 46. The classes of most critical importance at this time, in terms of the volume that would be required in a mobilization: duck, fine cotton goods (combed) and worsteds, have a small industry base today, and production in all three areas is in a downward trend.

The impact of imports has been serious, not just because they have taken over 15% of the U.S. broadwoven goods market, but also because our national policy has been pointed toward the turning over the growth in our home market to the less developed countries of the world as a first step toward their industrialization. Also the concentration of impor[illegible] certain sectors of the market has been highly damaging; e.g., the U.S. woolen and wo[illegible]ed industry has been largely liquidated as a result of competition from imports, plus the in-roads made in the last few years by knits. As a result, there is no longer a viable woolen and worsted industry upon which the military could count for the quantities of textiles that would be required in a mobilization.

The most serious aspect of this situation, however, lies in the resulting unattractiveness of the broadwoven goods industry as a potential area for capital investment in new mills. With the profit margins held down by low-price imports, there is little likelihood of growth other than that arising from the installation of more productive equipment in existing mills. Accordingly, looking into the 1980-85 time frame, selected as a base for this study, this industry will be providing a smaller and smaller part of the U.S. market, and in proportion to total consumer demand, will have less capacity to meet combined military and civilian demands in a future emergency.

A further disturbing factor with respect to the future is the fact that the U.S. textile machinery industry does not have complete machinery product lines to furnish the textile industry. Much of the special purpose machinery used in military fabric and yarn production is no longer available from U.S. firms. In a war period, spare parts of much of the machinery in U.S. mills would not be available from their foreign sources. This could cost production and cause serious delays in supplying military needs.

Raw Materials

Current trends in fiber consumption show the rapid rise in utilization of the non-cellulosic man-made fibers by the U. S. textile industry. This trend, based especially upon the fact that polyester staple is now in a competitive price area with the better cottons and the greatly expanded markets for fabrics and carpeting made from texturized filament yarns of polyester and nylon, can be expected to continue into the time frame projected for this study.

Military utilization of the man-made fibers has been increasing both in blends and as replacements for cotton in special uses, such as in load-carrying equipment.

However, looking into the 1980-85 time frame, the assessment of the energy outlook which has been made by the Committee of the U.S. Energy Outlook of the National Petroleum Council, and published in December 1972 by the U.S. Department of the Interior, has placed the entire situation with respect to supplies of petroleum and gas in a context which requires reassessment as to the necessity of using man-made fibers drawn from these raw materials.

In view of the seriousness of the potential balance of trade deficit in energy fuels that may exist by that time, and its consequences upon the military, political and economic security of the United States, it must be anticipated that too great dependence upon fibers drawn from petrochemical feedstocks could present undesirable hazards to the military services from a supply standpoint.

Accordingly, the desirability of keeping open all options with respect to the utilization of cotton in military textiles should be recognized and continued as a policy of the Department of the Army and the Department of Defense.

Conclusions

1. The production base of the textile industry can no longer be considered to be relatively static. Where long term planning is concerned, it must be recognized that mills making a particular product in one year may, in response to market changes, no longer be making that product, or be able to make it, even only a year or two later.

2. Since the functional performance requirements for military textiles essentially limit them at this time to broadwoven goods, the future of this segment of the textile industry is a matter of major concern to national defense.

3. Production of broadwoven goods has not been rising in recent years proportionate to the growth of consumer demand for textiles, nor is it likely, in the near future, to be an attractive area for investment of new capital for significant expansion. Imports, which can be expected to continue to expand beyond their present 15% of the market although at a somewhat reduced rate, and competition from knitted fabrics, constitute limiting factors on growth of broadwoven goods production.

4. Some of the segments of the broadwoven goods industry of most direct importance for military textiles (see Table XII) are quite limited in capacity, particularly duck, fine combed cotton goods and worsteds, and are in a downward trend.

5. The trend in the textile industry and the U.S. textile market toward increased use of the non-cellulosic man-made fibers, either in blend with the natural fibers or as replacements for them, will necessitate some redevelopment of present military textiles in order to keep sources of supply available.

6. From the standpoint of national security, too great a commitment to the man-made fibers should be regarded with caution when regarded from the standpoint of the time frame projected in this study, 1980-85. The balance of trade deficit in energy fuels which can be anticipated by that date could have serious consequences upon the military, political and economic security of the United States, since our country would become increasingly dependent on the political and economic policies of a relatively small number of countries in the Middle East. Under these conditions, it would appear to be a prudent course of action for the military to be prepared for the use of alternate textile fibers, the supply of which would not be dependent upon oil or gas, and which would require the minimum amount of energy for their conversion into military textiles. This would indicate the desirability for the military services to be able in such an emergency to obtain quickly large quantities of military textiles made from cotton and wool. From this standpoint, the maintenance of textile manufacturing facilities capable of producing textiles from cotton, and the continued use of textiles predominantly made from cotton by the military, would appear to be in the interests of national security.

7. The present policy of the military services with respect to the use of cotton (pg. 69 of the report) should be continued. It should be supported by positive actions by appropriate government authorities to (a) - minimize the fluctuations in the price of cotton which adversely affect its desirability to textile manufacturers; (b) - assure a carry-over of adequate size to meet possible military needs as to quantity, grade and staple at any time in the crop year.

8. The lack of a potential reserve of labor in the major textile manufacturing areas. which could well continue or intensify over the next several years, could pose a serious problem to achieving a high level of output on military textiles quickly in the event of mobilization.

9. Lack of a broad-based textile machinery industry within the United States, with so large a proportion of presently installed mill equipment having been made overseas, could create a serious spare parts problem in a crisis situation. Loss of production capacity during the early part of the period while domestic manufacturers tooled up to produce needed parts for foreign equipment could seriously limit the capability of the industry to reach high production levels quickly.

10. The industries which convert textiles into the end items used by troops: parachutes, protective combat clothing, uniforms, equipment, personnel armor, etc., can be expected to lose contact with military items during a prolonged period of peace. They may accordingly be ill-prepared to move quickly into production of military items in an emergency. Some industries which produce almost entirely for the military, such as those making parachutes, personnel armor, and large tents, may be so reduced in size as to be quite inadequate as a production base from which to provide large scale production.

11. (a) A broad-based research and development program to develop alternate textile materials which will be in consonance with industry's capabilities for large scale production within the projected time frame, 1980-85, and yet which will meet all critical and essential technical requirements should be undertaken as a matter of priority.

(b) In view of the rapid changes taking place in the industry on the one hand, and the need for prudent reserve about too great a commitment to man-made fibers based upon oil, of which a large part will have to be imported in the time frame suggested, such a research and development program should proceed along several lines simultaneously, including especially the upgrading of the performance of cotton textiles or limited mixtures of other fibers with cotton. The support of industry and the U.S. Department of Agriculture should be obtained on as broad a base as possible to assure the availability of materials conforming to all military needs.

12. The complexity of the textile and related industries and their unlikeness to the hard good industries which has baffled and frustrated so many military personnel who have not had previous relation to these industries, would indicate the need for a commodity training program, such as a graduate program in textiles at university level for officers who are to be assigned in the fields of procurement, supply or administration in this area. The success of the World War II Quartermaster textile and clothing operation was due largely to the fact that practically all officers involved in it were drawn from the textile and clothing industries. The availability of officers with such training in the future will be essential to effective operation of a future mobilization program.

13. (a) With respect to the first of the two parts of the basic question raised in this study, viz., the availability of a broad industry base to supply needed military textiles in large quantities quickly upon mobilization, it is clear that at present such a broad base does not exist for duck, fine combed cotton goods, or worsted uniform fabrics. Also, because of the special manufacturing equipment required to make these fabrics, very little conversion of other mills' capacity could be turned to producing them. Alternate materials are needed as either partial or total replacements for these materials.

(b) But even for total textile needs, there can be serious question whether conversion of the industry could be accomplished quickly enough, together with that of the industries which would have to convert textiles into the end items used by troops, to bring production up to usage rate by the end of a year, if large scale mobilization were necessary. As shown in this study, there are numerous unfavorable factors which could delay attainment of a required high level of production quickly. The repetition of what occurred during the Korean War, when quantity production could not be attained until the second year of the war, should be recognized as a potential hazard.

14. As to the other aspect of whether, if the conflict were prolonged, the industry base would be adequate to meet the needs both of the military and the civilian population, the answer is clearly negative. With a large segment of the total civilian demand now being met by imports, which can be expected to increase in coming years, the demands for military textiles would so limit the amount available to consumers that, with imports shut off, severe limitations upon civilian usage would be required. The resulting morale aspects and the problems of price controls, black markets, etc., could be serious as was demonstrated during World War II, where the supply situation was far less critical than it would be in the future or even today.

BIBLIOGRAPHY

1. Akins, James E., "The Oil Crisis: This Time the Wolf is Here", Foreign Affairs, New York, N.Y., April 1973.
2. American Textile Manufacturers' Institute, Inc., Textile Hi-Lights, Washington, D.C., Apr. 1973.
3. Brown, Glen F., Quartermaster Purchase of Wool Cloths and Blankets for World War II, Textile Series Report No. 1., Office of the Quartermaster General, Washington, DC., 6 Feb 1946.
4. Carsel, Wilfred, Wartime Apparel Price Control, Office of Price Administration, US Government Printing Office, Washington, DC. 1947.
5. Daily News Record, New York City, N.Y., 30 March 1972; 12 March 1973; 28 March 1973.
6. Defense Supply Association, Clothing and Textiles Seminar. Military Textiles — Will the Defense Department Have to Procure from Abroad? Washington, D.C., 26 October 1971.
7. Eighty-first Congress, 2nd Session, Senate Document No. 204. Mobilization Planning and the National Security (1950 - 60), prepared by the Legislative Reference Service of the Library of Congress. US Government Printing Office, Washington, D.C. 1950.
8. Eisenhower, Dwight D., Final Report of the Chief of Staff, United States Army to the Secretary of the Army, 7 February 1948.
9. Haggard, John V., Procurement of Clothing and Textiles. Q.M.C. Historical Studies, Series II. No. 3. Office of the Quartermaster General, Washington, D.C. 1957.
10. Kennedy, Stephen J., Goldman, Ralph, Slauta, John, The Carrying of Loads in an Infantry Company. US Army Natick Laboratories, Natick, Mass. April 1973.
11. National Cotton Council of America, Finding a Future for the U.S. Cotton Producer, Memphis, Tenn. March 1972.
12. National Petroleum Council, Committee on U.S. Energy Outlook, U.S. Energy Outlook, Washington, D.C., December 1972.
13. Nehmer, Stanley, "Reflections on the Past and Challenges of the Future", Remarks delivered at the New York Board of Trade Annual Textile Award Luncheon, November 27, 1972.
14. Office of the Quartermaster General, "Questions and Answers Regarding Department of Defense Duck and Webbing Pool", Washington, D.C., 7 March 1952.
15. Pitkin, Thomas M. and Rifkind, Herbert R., Procurement Planning in the Quartermaster Corps 1920 - 1940, and Quartermaster Corps Historical Studies No. 1., Office of the Quartermaster General, Washington, D.C., March 1943.
16. Quartermaster General, Office of The, Statistical Yearbook of the Quartermaster Corps, 1941 - 1945; 1950 - 53.
17. Small, J. O., Duck, Cotton; Fire, Water, Weather and Mildew Resistant, Office of the Quartermaster General, Washington, D.C., September 1945.
18. Stevens, Col. Robert T. and Butland, Ralph A., The Quartermaster Corps Duck and Webbing Pool, Office of the Quartermaster General, Washington, D.C. Feb. 1, 1944.

19. Textile Economics Bureau, Inc., "Textile Organon", New York, N.Y.

20. U.S. Army Natick Laboratories, Engineering Practice Study of Sheet, Bed and Pillowcase, Cotton and Polyester/Cotton, Project No. 7210-0144., Natick, Mass. April 27, 1972.

21. U.S. Army Natick Laboratories, "Policy on Use of Cotton in Military Textile Items", Natick, Mass., July 1966.

22. U.S. Defense Personnel Support Center, Impact of the Southeast Asia Situation on the Defense Personnel Support Center, 1 July 1965 - 31 December 1966, Philadelphia, Pa. 1966.

23. U.S. Defense Personnel Support Center, Production Leadtime Estimates, DSA DPSC-P Handbook 4235.1, Philadelphia, Pa., July 1969.

24. U.S. Defense Supply Agency, Material Management Manual, DSAM 4140.3, Alexandria, Va., 1973.

25. U.S. Defense Supply Agency, Report on the Management of Parachutes (FSC-1670)Within the Department of Defense, Alexandria, Va., March 1966.

26. U.S. Department of Agriculture, Economic Research Service, Statistics on Cotton and Related Data, 1930 - 67. Statistical Bulletin No. 417., Washington, D.C., March 1968. Also supplement for 1972.

27. U.S. Department of Agriculture, Economic Research Service, Wool Statistics and Related Data, 1930 - 69. Statistical Bulletin No. 455., Washington, D.C., June 1970. Also supplement for 1972.

28. U.S. Department of the Army, Field Manual FM 31.70, Basic Cold Weather Manual, Apr. 1968.

29. U.S. Department of the Army, Field Manual FM 21-15, Care and Use of Individual Equipment, August 1972.

30. U.S. Department of Commerce, Correlation Textile and Apparel Categories with Tariff Schedules of the United States - Annotated. Washington, D.C., March 1972.

31. U.S. Department of Commerce, U.S. General Imports, Cotton Manufactures, TQ 2010, Washington, D. C.

32. U.S. Department of Commerce, U.S. General Imports. Man-Made Fibers and Manufacturers, Washington, D.C. TQ 2310

33. U.S. Department of Commerce, U.S. General Imports. Wool Manufacturers, TQ 2210, Washington, D.C.

34. U.S. Department of Commerce, Bureau of the Census, Annual Survey of Manufacturers, Expenditures for New Plant and Equipment, Washington, D.C.

35. U.S. Department of Commerce, Bureau of the Census, Current Industrial Reports, Cotton Broadwoven Gray Goods, Series MQ-22T.1, Washington, D.C.

36. U.S. Department of Commerce, Bureau of the Census, Current Industrial Reports, Man-made Fiber Broadwoven Gray Goods, Series MQ-22T.2.

37. U.S. Department of Commerce, Bureau of the Census, Current Industrial Reports, Wool Broadwoven Goods, Series MQ-22T.3, Washington, D.C.

38. U.S. Department of Commerce, Bureau of the Census, Current Industrial Reports, Cotton Broadwoven Fabrics - Weight and Width of Fabrics, Series MQ-22T.1 Supplement. Washington, D.C.

39. U.S. Department of Commerce, Bureau of the Census, Current Industrial Reports, Man-made Fiber Broadwoven Goods - Average Weight and Width of Fabric, Series MQ-22T.2 Supplement. Washington, D.C.

40. U.S. Department of Commerce, Bureau of the Census, Population Estimates and Projections, Series P-25, No. 470. Washington, D.C., November 1971.

41. U.S. Department of Defense, OASD Comptroller, Directorate for Information Operations, Selected Manpower Statistics, April 15, 1972.

42. Wellford, Dabney S., The Economic Outlook for U.S. Cotton 1973, National Cotton Council of America, Memphis, Tenn. January 29, 1973.

APPENDIX A

TECHNICAL REQUIREMENTS FOR MILITARY TEXTILES

APPENDIX A

TECHNICAL REQUIREMENTS FOR MILITARY TEXTILES

The technical requirements for the textiles used in military uniforms, combat clothing/equipment systems, tents and paulins, and parachutes which are listed in this Appendix have been identified according to the following three-way classification:

Critical

Requirements which cannot be compromised without endangering life, health or military capability.

Essential

Requirements essential to end item or system performance, the absence of which would adversely affect the accomplishment of a military mission.

Desirable

Requirements which enhance the protection of the user, extend the life of the item, or build morale through improving the military appearance of the troops.

1. Service Uniforms

The technical requirements for a satisfactory service uniform fabric can be stated as follows:

TABLE A-1

TECHNICAL REQUIREMENTS FOR UNIFORM FABRICS

Essential

Appearance

- Excelient appearance when properly tailored.
- Retention of good appearance throughout prolonged wear.
- Ability to return to original appearance after being worn, allowed to hang and/or be pressed.
- Resistant to wrinkling.
- Resistant to stretching or sagging.
- Resistant to seam puckering.
- Good drapability.
- Crease retention in trousers.

Body

- Sufficient body to support insignia, campaign bars and other ornamentation without sagging or distortion.

Care

- Resistant to soiling.
- Easy to clean.
- Capable of alteration without leaving stitch or crease marks.

Comfort

- Water vapor permeable
- Of proper weight for the season, taking into account limitations on heating of housing in wartime.

Color

- Dyeable to exact shade match with fast colors.

Desirable

- Tear resistant
- Abrasion resistant
- Resistant to shining
- Resistant to pilling
- Resistant to snagging
- Resistant to melting from cigarette ash

Traditionally, wool has been the fiber of choice for military uniforms. It possesses most of the essential and desirable properties for making a good uniform fabric. Blends of wool with man-made fibers, particularly polyester, have in recent years produced good uniform fabrics with some advantage in resistance to wrinkling. It is to be expected that, in the future, satisfactory uniform fabrics will increasingly be made by utilizing of man-made fibers, either in blends or 100% man-made. Summer semi-dress uniforms, while presently made from all-cotton fabrics, can be expected in the near future to be changed to durable press polyester/cotton fabrics.

The principal fabrics currently being used in men's Army uniforms are listed in Table A-2.

TABLE A-2

TEXTILES USED IN ARMY MEN'S UNIFORMS

Winter Uniform	No. Issued	Fabrics Used	Sq. Yards per 1000 Men
Winter Uniform (Cap, coat and trousers)	1	Cloth, wool, serge	5342
		Cloth, rayon, lining	2399
		Silisia	1648
		Other woven textiles	1489
Overcoat	1	Cloth, wool, gabardine	5050
		Cloth, wool flannel, lining	1432
		Cloth, rayon, lining	2796
		Other woven textiles	2269
Raincoat	1	Cloth, polyester/cotton poplin	6250
		Other woven textiles	90
Shirt	2	Cloth, polyester/cotton broadcloth	4436
		Interlining	436
Drawers, Boxer Style or	4	Cloth, cotton 78x78 print cloth	2397
Drawers, Brief Style		Cloth, rib-knit, cotton	—
Undershirt T-shirt	4	Cloth, jersey knit, cotton	—
Belt, trousers	1	Webbing, cotton	—
Necktie	1	Cloth, polyester/wool, tropical	264
		Cloth, wool, interlining	14
Shoes	1	Linings	165
Socks	3		—
		Total — woven fabrics, winter uniform	36,877
Summer Uniform			
Summer uniform (Cap, coat and trousers)	1	Cloth, polyester/wool, tropical	5708
		Cloth, rayon, lining	1996
		Silisia	1698
		Other woven textiles	1800

Summer Uniform	No. Issued	Fabrics Used	Sq. Yards per 1000 Men
Semi-dress uniform (Shirt and trousers)	3	Cloth, cotton, uniform twill	15,525
		Other woven textiles	2,454
Utility uniform (Shirt & trousers)	2	Cloth, cotton, sateen	11,216
		Total woven fabrics for summer & utility uniforms	40,397
		Total — woven fabrics required for initial issue	77,274

The figures shown in Table A-2 of 36.9 sq yds for the winter uniform, and 40.4 sq yds for the summer and utility uniforms, with a total of 77.3 sq yds per man are useful only in giving an overall perspective of the kinds of woven textiles required for military uniforms and the relative amounts of each. The actual requirements would need to take into account basic stockage requirements for sized items (approximately 50% above troop strength), the option given to troops to purchase additional uniforms, which usually is necessary, the amounts required to fill the pipe-line, including intermediate stockage points, and many other factors.

In general, the technical requirements for women's uniforms and for the uniforms of the other military services, correspond to those listed above. The overall yardage figures per uniform would not differ greatly, although the particular fabrics may be different. New fabrics now under evaluation by the Army and also by the other military services, will undoubtedly in time, replace many of those listed above.

Military uniforms serve to achieve uniformity in appearance and a sense of belonging to a military service, as well as give the soldier a feeling of pride in his unit, pride in the Army and pride in his country. For this use, fabrics are needed which are both very durable and which will provide a fine-appearing uniform when well-tailored and well-fitted.

2. Protective Clothing and Equipment Systems

Protective clothing and equipment systems include all items of clothing, headwear, handwear and footwear which provide passive protection to the individual soldier against both natural environments and enemy-imposed hazards, including chemical warfare protective clothing against percutaneous agents, personnel armor, and all items of personal military equipment used by the individual soldier, such as load carrying equipment, sleeping gear, and related items.

The separation of combat protective clothing from the Army's service uniform, which came with the adoption of the Army Green uniform in 1954, has made possible concentration upon enhancing the functional and protective properties in the textiles used in combat clothing.

Provision of higher levels of protection in the soldier's clothing system, realized in part during World War II, by textiles specifically developed to give greater protection against the natural environment, has now become a necessity due to technological advances in munitions and weaponry which have greatly increased the power of the offensive. What are now required are multi-functional textile materials, having the capability through the fiber, the fabric, and a functional finish of providing simultaneously more than one type of protection.

A summary of the required technical characteristics for nine elements of the soldier's total protective clothing/equipment system is shown in Table A-3. Detailed discussion of these technical requirements follows, together with explanation of the function of some of these requirements. It will be noted that, in some instances, the requirements exceed the performance of presently used fabrics. In these cases, it is anticipated that the more demanding requirements are within the long range capability of the industry to meet.

TABLE A-3
PROTECTIVE CLOTHING AND EQUIPMENT SYSTEMS

Technical Requirements	Hot Weather Clothing	Cold Wea. Outer Clothing	Extreme Cold Wea. Clothing	Cold Wea. Insulating Layers	Desert Clothing	Army Aviators Clothing	Combat Vehicle Crew Clo.	Personal Equipment Fabrics	Webbing	Utility Uniforms
Water vapor permeable	Critical	Critical	Critical	Critical	Critical	Critical	Critical	Essential		Critical
Light Weight	Critical	Critical	Critical	Critical	Critical	Critical	Critical	Critical	Critical	Essential
Water Absorbent	Critical				Critical	Essential	Essential			Essential
Water Repellent		Critical	Critical					Essential		
Wind Resistant (A) Tightly Woven (B)	Essential (B)	Critical (A)	Critical (A)		Critical (A)		Essential (B)	Essential (B)		
Thin	Critical	Critical	Critical			Desirable	Desirable			Desirable
Tear Resistant	Essential	Essential	Essential		Essential	Essential	Essential	Essential		Essential
Quick Drying (A) Low water pick-up (B)	Essential (A)	Essential (B)	Essential (B)					Essential (B)	Essential (B)	Desirable
Good Drapability	Essential	Essential	Essential		Essential	Essential	Essential			Essential
Abrasion Resistant	Desirable	Essential	Desirable		Essential	Essential	Essential	Essential	Essential	Essential
Dyeable with fast Camouflage Colors	Essential	Essential	Essential	Essential	Essential	Essential	Essential	Essential	Essential	Essential
Easy to Clean	Essential	Essential	Essential	Essential	Essential	Essential	Essential	Essential	Essential	Essential
Fire Resistant	Desirable	Desirable	Desirable	Desirable	Desirable	Critical	Critical	Desirable	Desirable	Desirable
Thermal Resistant	Desirable	Desirable	Desirable	Desirable	Desirable	Desirable	Desirable	Desirable	Desirable	Desirable
Melt Resistant	Desirable	Desirable	Desirable	Desirable	Desirable	Critical	Critical	Desirable	Desirable	Desirable
Mildew Resistant	Desirable	Desirable	Desirable	Desirable	Desirable	Desirable	Desirable	Essential	Essential	Desirable
Soft	Essential			Essential		Desirable	Desirable			
Good Appearance	Desirable	Desirable	Desirable		Desirable	Desirable	Desirable			Desirable

3. Hot Weather Combat Clothing

The technical requirements for the textiles used in the Army's hot weather combat clothing system as listed in Table A-3 are further detailed below:

TABLE A-4

TECHNICAL REQUIREMENTS FOR TEXTILES

USED IN HOT WEATHER COMBAT CLOTHING

Critical	
— Water vapor permeable	— Able to pass body moisture at rates not less than 35 $g/m^2/hr$ at 70^oF and 55% RH
— Light weight	— Not over 4.5 oz/yd^2
— Water absorbent	— Able to wet out rapidly and to bring body moisture to outer surface for evaporative cooling at rates in excess of 5 $g/ft^2/min.$ at 70^oF and 65% RH
— Thin	— Not over .010 inches thick
Essential	
— Tear Resistant	— Not less than 3 x 3 lbs. (Elmendorf)
— Quick drying	
— Tightly woven	— Interstice size and contour of proportions to prevent mosquitoes from biting through; usually met by air permeability of 6 $ft^3/ft^2/min.$ or less.
— Good drapability	— Able to cling close to the body with minimum interference with body movement.
— Soft	— Free from scratchiness
— Dyeable with fast camouflage colors	
— Easy to clean	
Desirable	
— Abrasion resistant	
— Melt resistant	
— Fire and thermal resistant	
— Mildew resistant	
— Good appearance	

The major concern in the designing of a combat uniform for hot, humid climates is to reduce the hazard of heat stress that may cause heat casualties. For the body to remain in thermal equilibrium, the amount of heat gained from the environment and from energy expenditure by the individual must be equalled by the amount of heat dissipated. Since the body's main defense against heat stress is through the evaporation of sweat poured out on the skin's surface by the sweat glands, the clothing system must be such as to assist in this method of body cooling so that the sweat is utilized as efficiently as possible.

The four fabric properties which contribute to efficient use of the body's sweat for cooling of the skin surface have been listed in Table A-4 as critical. The fabric should be as thin as practicable, so that the cooling effect resulting from evaporation is as close to the skin surface as possible. It should be water absorbent so that the moisture is wicked over a broad surface area for evaporation. Under conditions of frequent wetting, it is essential that the fabric be able to dry quickly, since there is so much moisture to contend with from showers, vegetation, streams, and perspiration. It must also be water vapor permeable, and it should be as light in weight as practicable to hold down the overall load of the soldier.

The factor that most limits lightness in weight is the need to maintain reasonable tear resistance. This property is further compromised by the need of the fabric to be tightly woven with uniformly small interstices to prevent mosquitoes from biting through it.

The rip-stop cotton poplin used in the tropical combat uniforms furnished to our troops in Vietnam served the purpose very well. That uniform was one of the best-liked items the troops had. The jacket and trousers, with ample cargo pockets in each, only weighed two pounds. It lacked durability, however, due to relatively low tear strength.

This rip-stop poplin made from combed 40's, 2-ply yarns in the warp , and 21 singles filling has been made in the combed goods section of the textile industry which has been largely liquidated in recent years, both as a result of imports and changes in the market away from combed all-cotton fabrics, and only intermittent demand from the military services. It is doubtful if it could be produced readily again in the quantities purchased to support the war in Vietnam, amounting to over 110 million yards.

A potential substitute for this poplin would be a nylon-cotton blend using singles yarns in warp and filling. A lightweight 70/30 nylon/cotton fabric that would provide thermal protection similar to that provided in cold weather clothing has been tested experimentally.

TABLE A-5

TEXTILES USED IN HOT WEATHER COMBAT CLOTHING

Item	No. Issued	Fabrics Used	Sq. Yds. per 1000 men
Boot, Combat Tropical	2	Cotton/nylon duck	644
		Cloth, cotton, twill	
Cap, hot weather	1	Cloth, polyester/rayon	217
		Cloth, oxford, nylon	32
Coat, hot weather poplin	5	Cloth, poplin, ripstop	18,375
Hat & insect net	1	Cloth, poplin, ripstop	781
		Netting, nylon tricot	—
Poncho	1	Cloth, ripstop, nylon	6060
		Cloth, cotton	174
Poncho Liner	1	Cloth, ripstop, nylon	9246
		Polyester batting	—
Shirt, sleeping	1	Cloth, knitted, nylon and triacetate	—
		Cloth, nylon, rib-knit	—
		Cloth, cotton, silesia	92
Socks, wool, cushion sole or	5		—
Socks, nylon			—
Trousers, hot weather poplin	5	Cloth, poplin, ripstop	18,430
		Total, woven fabrics	55,271

As indicated above in respect to Table A-2 for fabrics for uniforms, these figures showing the yardage required to outfit each man are useful only to give an overall perspective of the kinds and relative amounts of woven textiles required for troops being outfitted to serve in such climatic areas. It will be noted that the underwear, web belt, and other accessories of the summer uniform are not repeated in this Table.

4. Cold Weather Combat Clothing

The technical requirements for the textiles used in the Army's cold weather combat clothing system, as listed in Table A-3 are further detailed below:

TABLE A-6

TECHNICAL REQUIREMENTS FOR TEXTILES

USED IN COLD WEATHER COMBAT CLOTHING

OUTER LAYERS	
Critical	
— Water vapor permeable	— Able to pass body moisture at rates not less than 35 $g/m^2/hr$ at 60^oF and 55% RH, and preferably higher.
— Water repellent	— Resistant to rains of one inch/hr for 8 hours.
— Wind resistant	— Air permeability less than 6 $ft^3/ft^2/min$.
— Light weight	— Not over 6 oz/yd^2.
— Thin	— Not over .015 inches thick.
Essential	
— Tear resistant	— not less than 6 x 6 lbs (Elmendorf)
— Abrasion resistant	
— Low water pick-up	
— Good drapability	— Not stiff so as to interfere with body movements, even at extreme cold temperatures
— Dyeable with fast camouflage colors	
— Easy to clean	
Desirable	
— Fire and thermal resistant	
— Melt resistant	
— Mildew resistant	
— Good appearance	
INSULATING LAYERS	
Critical	
— Water vapor permeable	— Same as for outer layers
— Light weight	— Batting type preferred
Essential	
— Quick drying	
— Low water pick-up	

TABLE A-6 (Continued)

Essential

- Dyeable surface fabric with fast camouflage colors
- Low friction of surface fabric
- Soft — Not stiff so as to require expenditure of extra energy for body movements
- Easy to clean

Desirable

- Melt resistant
- Flame and thermal resistant
- Mildew resistant

EXTREME COLD WEATHER CLOTHING

OUTER LAYERS

Critical

- Light weight — Not over 4 oz/yd^2
- Tear resistant — Not less than 3 x 3 lbs. (Elmendorf)

Essential

- Melt resistant

(Other requirements the same as above)

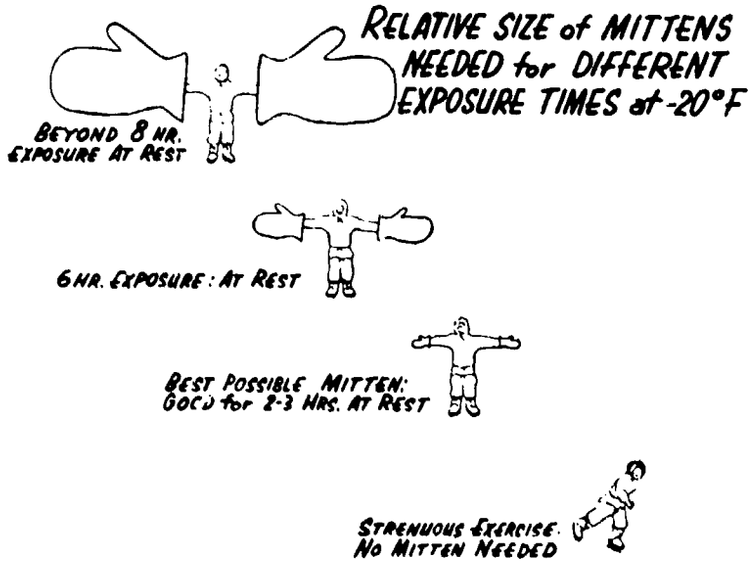
SNOW CAMOUFLAGE COVER

Critical

- Light weight — Not over 2 oz/yd^2
- Opaque when wet or dry

(Other requirements the same as above)

A protective clothing system for cold climates must be able to provide three critical types of protection: to insulate against the cold and prevent loss of body heat; to protect against wind and rain; and to be adjustable to the wide range of temperature (from +60°F to —60°F) and the wide range of energy expenditure, from 60 kcal/hr when sleeping, 100 kcal/hr for sentry duty, 250-300 kcal/hr when patrolling, to 425-600 kcal/hr in an assault. The relationship between the level of body activity and the requirement for effective insulation for keeping warm is well shown in the classic illustration of the mittens.



In the cold, it is essential to be able to get rid of excess body heat generated by a high level of work without having excess perspiration absorbed into the clothing system, which would thereby reduce its insulating efficiency, and leave the soldier exposed to the discomfort of after-exercise chill and increase his risk of cold injury. Through the front opening of the Army's present cold weather clothing system, which the man can open up when he is active in order to cool himself off, the use of vents at the wrist and neck, the use of suspenders so that his trousers and drawers are not constricted at the waist, and the use of water vapor permeable fabrics, every conventional means is taken to enable him to avoid over-heating.

Cold climates have been traditionally divided into cold-wet areas where protection against rain is critical, and cold-dry areas where the temperature would be below freezing most of the time and the basic problem is that of providing extra insulation against the cold. The need to cover this wide range of 120°F in temperature has been met by use of a layer system of clothing, in which overgarments are provided for both the cold-wet and cold-dry ensembles. In this way, and with the option of opening up his clothing system to cool-off, the man can adjust his clothing to meet his immediate needs for keeping warm or dissipating body heat. Here it is important to keep in mind that the needs of a soldier in combat in such climates, where he is subject to exposure to the extremes of climate for days on end, is very different from that of a typical sportsman, who will have access to warm shelter or can go home when the weather is extreme. Hence, extrapolation from sportsmen's clothes to military functional, protective clothing is seldom valid because of the much more severe and more prolonged demands placed upon military clothing both for performance and durability.

For protection against rain and wind, tightly woven fabrics are required to which a durable water repellent must be applied. Fabric tightness may be defined as the ratio of the actual cover factor of a fabric to the maximum cover factor possible for such a weave. It is one of the most critical factors controlling the performance, not only of the clothing fabrics of the cold weather clothing system, but also the fabrics used in hot weather and desert clothing, the fabrics used in tents, and those used in all kinds of covers. Water resistance is critically influenced by the tightness of weave. The relationship in many types of fabrics is parabolic in nature. If the tightness of the fabric falls below a certain critical value, there is a marked increase in water penetration and the fabric becomes relatively useless for protection from rainfall.

Wind resistance is another factor that is closely related to the tightness of textile fabrics. For wind and water resistance applications, maximum tightness is required. With respect to tightly woven fabric, it is important to note that moisture vapor diffusion through fabrics which is a main avenue for dissipation of body moisture is not adversely influenced by fabric tightness.

A double layer of tightly woven, water repellent fabric is used in the field coat and water repellent thread must also be used to insure that seams will be of equal water repellency to the fabrics. Because of the importance that the shell components of the clothing system must maintain their integrity in a cold climate to provide wind and rain resistance, both abrasion resistance and tear resistance are listed as essential requirements.

The 8½ ounce nylon/cotton (NYCO) sateen presently used in the outer layer of the cold weather clothing system represents a transition from the combed all-cotton oxford or sateen weaves formerly used for this purpose. Being spun of singles yarn, it moves away from dependence upon fine combed ply yarns and can be produced in a broader segment of the industry. Its effectiveness in water resistance is dependent, however, upon yarn uniformity in spinning. This fabric also has a desirable property in being significantly resistant to the thermal effects of nuclear weapons. This property derives from the combination of the nylon and cotton in the 50/50 blend.

Good drapability in the outer layer and softness in the insulating layer are listed as essential for the cold climate clothing ensemble, so as to minimize the work involved in moving the clothing layers when moving the arms or walking. Also, for the same reason, low friction on the insulating layers is essential. In general, the extra layers for the extreme cold should be lighter in weight and will not require the degree of abrasion resistanceneeded in the cold weather ensemble since they are less subject to severe wear. However, melt resistance becomes essential in these outer layers because of the hazard involved in drying clothes or the man warming himself near a stove or open fire.

What has been outlined above with respect to the technical requirements for the textiles used in cold weather clothing is applicable equally to the textiles used in the sleeping bag. The outer fabric requires the same technical characteristics. Current development work should eliminate the need for a separate outer case.

With respect to the filling material, it should be noted that the major functional requirement in a military sleeping bag is to be both compresssible to relatively small bulk to permit ease of carrying, and also to be able to be fluffed up to large bulk to provide a thick, insulating layer when in use. It is to be expected that, in the future, a suitable synthetic filling material should be available to relieve dependence upon waterfowl feathers and down.

In summary, it will be noted that in both the cold weather and the hot weather combat clothing systems, tightness of weave and lightness of weight stand out as critical requirements. Tightness of weave is required in fabrics for the cold weather system to provide effective water resistance and wind resistance. It is also the technical characteristic that provides mosquito protection in the hot weather clothing system. In fact, the levels of tightness approach the limits of weavability which would indicate that knitted structures present no possibility of being able to supplant woven textiles for these uses.

Another important fact is that for comfort in the hot weather system, a cellulosic absorbent fiber is needed, and similarly in the cold weather system, cellulosic fibers are needed to provide the base for the permanent, launderable, water repellent finish. While fabrics made wholly of man-made fibers may be developed which will possess these critical characteristics, they are not available at this time, although blends may combine the best features of both types of fibers. The important fact to be kept in mind is that these are critical technical requirements which must be met to the maximum degree. The other essential and desirable characteristics should also be sought in research and development directed toward providing textiles which could be produced on a broad base in the industry both in a stable, peace-time situation and in the event of a future mobilization build-up.

The textiles currently being used in these cold climate clothing ensembles are listed in Table A-7 below:

TABLE A-7

TEXTILES USED IN COLD WEATHER AND EXTREME COLD WEATHER COMBAT CLOTHING

Item	No. Issued	Fabrics Used	Sq. Yds. per 1000 men
Boot, combat, leather	2	Cloth, cotton, twill	1220
Boot, insulated, cold weather, black	1	Cloth, cotton, muslin	45
		Cloth, cotton, osnaburg	729
		Cloth, fleece, wool face	595
		Cloth, nylon, twill	65
Cap, insulating, helmet liner	1	Cloth, oxford, cotton/nylon	454
		Cloth, acrylic	120
Coat, cold weather, cotton/nylon	1	Cloth, Nyco sateen	4151
		Cloth, oxford	2631
		Cloth, oxford, cotton warp	399
		Cloth, cotton, buckram	86
Liner, coat, cold weather	1	Cloth, ripstop, nylon	4500
		Cloth, oxford, nylon	293
		Batting, polyester	
Trousers, cotton/ nylon, cold weather	2	Cloth, Nyco sateen	7236
Liner, trousers, cold weather	1	Cloth, ripstop, nylon	4510
		Cloth, oxford, nylon	141
		Batting, polyester	
Shirt, flannel	2	Cloth, flannel, wool/nylon	5124
		Cloth, silesia cotton	208
Trousers, wool serge	2	Cloth, serge, wool	5000
		Cloth, drill, cotton	1144
		Cloth, silesia, cotton	160
Undershirt, 50% wool/50% cotton	2		
Drawers, 50% wool/50% cotton	2		
Socks, wool cushion sole	2		
Muffler, wool	1		
Suspenders, trousers scissors back	1		
Poncho	1	Cloth, ripstop, nylon	6060
Glove, Inserts	2		

Item	No. Issued	Fabrics Used	Sq. Yds. per 1000 men
EQUIPMENT			
Bag, waterproof, clothing	1	Cloth, plain weave, nylon	1660
Sleeping bag, mountain	1	Cloth, balloon, cotton	9035
		Cloth, cheesecloth, cotton	4150
Mattress, pneumatic	1	Cloth, parachute, nylon	5000
Case, sleeping bag	1	Cloth, oxford, wind resistant	5957
		Total, woven fabrics, Cold weather ensemble	70,671
EXTREME COLD WEATHER EQUIPMENT			
Boot, insulated, cold weather, white	1	(additional cloth - over black boot)	535
Hood, extreme cold weather	1	Cloth, oxford, cotton/nylon	1230
		Cloth, buckram, cotton	200
		Cloth, fleece	1560
Parka, extreme cold weather	1	Cloth, oxford, cotton/nylon	5362
		Cloth, flannel	422
		Cloth, buckram, cotton	338
Liner, parka, extreme cold weather	1	Cloth, ripstop, nylon	7250
		Cloth, oxford, nylon	78
		Batting, polyester	
Mitten set, arctic	1	Cloth, wind resistant, cotton	676
		Cloth, pile, alpaca	87
		Cloth, ripstop, nylon	1306
		Batting, polyester	
Mitten Insert, trigger finger	1		
Sleeping bag, arctic	1	Cloth, balloon, cotton	10,080
		Cloth, cheesecloth, cotton	4850
CAMOUFLAGE, ARCTIC			
Parka, snow camouflage white	1	Cloth, cotton, permeable	5000
Trousers, white, snow camouflage	1	Cloth, oxford, cotton/nylon	3745
Liner, trousers, snow camouflage, white	1	Cloth, ripstop, nylon	8000
		Cloth, oxford, nylon	400
		Batting, polyester	
Mitten Shells, white	1	Cloth, cotton, permeable	611
		Total, woven fabrics--Extreme Cold and Snow Camouflage	51,730
Total — Cold Climates and Extra for Extreme Cold Climates —			122,401

It will be noted from Table A-7 that not only are there more items in the cold weather clothing list, but that the total yardage per man of 70.7 yards for cold weather, and an extra 51.7 yards for extreme cold weather is based upon minimum issue of only one issued item for most items, and at the most two.

The yardage per man for hot weather clothing of 55.3 yards (Table A-5) is based upon issue of 5 coats and trousers, as was found necessary in Vietnam. On a comparable basis of only 2 per man, the hot weather requirement would be only 33.2 yards per man as compared with 70.7 yards for cold weather, and 122.4 yards for extreme cold.

Thus, it will be clear that the problem of mobilization will be far greater in its impact upon the textile industry, if the projected combat is to occur in cold climates, as compared with hot climates, even taking into consideration some possible differences in required rates of replacement.

5. Desert Combat Clothing

The technical requirements for the textiles used in a uniform to be worn in areas classified as deserts should conform to the following:

TABLE A-8

TECHNICAL REQUIREMENTS FOR TEXTILES USED IN DESERT UNIFORMS

Critical	
— Water vapor permeable	—
— Light weight	— Not over 7 oz/yd^2
— Water absorbent	
— Tightly woven	— Able to block solar radiation and penetration by wind-blown sand
Essential	
— Tear resistant	— Not less than 6 x 6 lbs. (Elmendorf)
— Quick drying	
— Abrasion resistant	
— Good drapability	
— Easy to clean	
— Dyeable with fast camouflage colors	
Desirable	
— Fire and thermal resistant	
— Mildew resistant	
— Good appearance	

Deserts are areas where water is scarce, sunshine is intense, air temperatures often exceed body temperatures, the terrain is rocky and sandy, wind is often high and visibility both on the ground and from the air is exceptionally good at great distances. Accordingly, the clothing system must contribute in every practicable way toward maintaining the man in thermal balance, and also protecting him from observation.

Currently the Army is in the process of developing desert combat clothing which will have optimum camouflage characteristics and will be so designed as to deal, as well as possible, with the problem of thermal balance. The fact that diurnal temperature fluctuations may amount to as much as seventy or more degrees, and that many desert areas are subject to cold winters requires a clothing system with adjustable insulation. Generally speaking, the fabrics required should not need to differ significantly from those required for cold climates, except for omission of water repellency.

6. Army Aviators' and Combat Vehicle Crewmen's Uniforms

The major technical requirements for the textile fabrics used in Army aviators' and combat vehicle crewmen's uniforms are to protect against fire, either a flash fire or a fuel fire, and to make the uniform as comfortable as possible under operational conditions.

TABLE A-9

TECHNICAL REQUIREMENTS FOR TEXTILES
USED IN UNIFORMS FOR ARMY AVIATORS AND COMBAT VEHICLE CREWMEN

Critical

- Fire Resistant
- Melt Resistant
- Water vapor permeable
- Light weight

Essential

- Water absorbent
- Tear resistant
- Abrasion resistant
- Good drapability
- Easy to clean
- Dyeable with fast camouflage colors

Desirable

- Thin
- Thermal resistant
- Mildew resistant
- Soft
- Good appearance

The requirement for fire protection of Army aviators andcombat vehicle crewmen is a critical one, and cannot be compromised. For aircrewmen, the major hazard is a fuel fire in the event of a crash; for combat vehicle crewmen, either a flash fire or a fuel fire. Fire resistance requires that the fabric be resistant to flaming, be self-extinguishing and act to reduce thermal transfer through the fabric to the skin surface. Melt resistance requires that the fiber not form molten globules which could cause deep skin burns if they come in contact with the skin surface, or aid in the spread of flames.

Flame resistance to the degree required for effective protection may require a two-layer fabric system. This may be in the form of an outer garment and fire resistant underwear, or a double fabric layer of lightweight, thin fabrics in preference to a single thick fabric, thereby taking advantage of the air layer between the fabrics to resist thermal transfer, and the better softness and comfort of thinner fabrics. It should be noted that the handwear and footgear must also be comparably fire resistant.

Both types of duty involve working in confined spaces where the heat may be excessive and the psychological stress severe. The fabric system, accordingly, should be one which will assist the body to remain in thermal balance by efficient utilization of the man's sweat for cooling. An ideal fiber would be one which, in addition to being fire resistant to a high degree, would also be water absorbent, lightweight, soft and generally comfortable. Also, because of the body contact with equipment and metal surfaces, especially in the case of tankers when entering and exiting from the vehicle, good tear and abrasion resistance are essential.

Presently the textile industry is placing great emphasis upon developing fiber and fabric systems which afford a high level of fire retardance, in compliance with the Flammable Fabrics Act. In addition, the military services, in their search for means of providing protection against crash and flash fires, are carrying out research and development to produce higher performance fibers. In view of this dual emphasis, it may be anticipated that, at a future date, a fiber having the technical requirements indicated above will be available in adequate quantities to meet military requirements. Currently a high temperature resistant polyamide fiber is being used in these clothing systems.

7. Chemical Warfare Protective Clothing

The development during World War II, and in the years since then, of highly lethal chemical warfare agents which act percutaneously, has created a new dimension of requirements for protection of the soldier in the event that chemical warfare should come to be employed in some future conflict. The effectiveness of the agents themselves increases the possibility of their being used. Accordingly, the provision of effective protective clothing must be planned as an important contingency requirement.

Currently, the best mechanism for dealing with these agents is adsorption by activated carbon. What is required is a way to place it in the clothing in such a way that it can function properly, and so that it will remain active and not become poisoned by the body's sweat or the dirt of the battlefield. One way of utilizing it is by impregnating it in a foam placed between two layers of fabric to preserve it from abrasion. Another possible way to utilize it would be to incorporate it in a textile fiber which could then be made into a protective fabric. Another mechanism for dealing with such agents would be to modify a textile fiber so that it would have the ability to react with and neutralize such agents.

Aside from this property of providing specific protection against chemical warfare agents, the clothing system with which it is used should have the appropriate environmental protection and other characteristics of the clothing systems outlined above.

8. Personnel Armor

Textiles are currently being used in personnel armor in four ways: as the ballistic material in the body armor vest; as the cover material for the vest; as the ballistic material in the plastic molded helmet liner; and as the reinforcing material in the doron plastic laminate backing for ceramic armor. A further possible future use of textiles in body armor is for the entire helmet, replacing the present system of Hadfield steel helmet with a molded nylon liner.

Textiles provide the greatest potential below 2 or 3 pounds per square foot. Above that weight range, harder materials (glass, ceramic, metal) have both greater stopping power and energy extraction capability. Ceramic body armor which will stop small arms fire (30 cal ball) weighs slightly less than 6 lbs/ft^2. The primary role of textiles in personnel armor, accordingly, is that of protecting against fragmentation weapons and small higher velocity missiles, and in spall shields and in back-up for hard surface armor. Since only partial protection can be provided within acceptable weight limits, definite requirements for ballistic performance of the textile material cannot be given; it can only be said that the material should provide the highest possible resistance to fragments of all sizes; e.g., from 2 to 64 grams having as high velocities as can be stopped with acceptable weights and thicknesses of the textile material.

Other technical requirements for textile materials used in fragmentation protective body armor are as follows:

TABLE A-10

TECHNICAL REQUIREMENTS FOR TEXTILES

FOR FRAGMENTATION PROTECTIVE BODY ARMOR

Critical

- High stopping power
- High energy extraction capability

Essential

- Water vapor permeable
- Low water pick-up
- Easy to fabricate
- Dyeable with fast camouflage colors

Desirable

- Easy to clean
- Flame resistant

9. Protection Against the Thermal Effects of Nuclear Weapons

This requirement for protection which was given a priority in the early 1950's can apparently now be regarded as only "Desirable". However, it is possible that with the proliferation of knowledge about nuclear weapons, and with the increase in the use of nuclear power to meet the world's energy crisis, with accompanying production of nuclear materials for weapons as a by-product, it is quite possible that the threat of nuclear warfare may grow. While this threat may be kept under control by the major nuclear powers, it is not beyond possibility that some smaller nation may resort to the use of nuclear weapons in the settlement of a local dispute. This may create a hazard that will necessitate the availability of protection in the soldier's clothing against the thermal effects of such weapons.

The technical research in this area, conducted during the 1950's by Natick Laboratories, has laid the basis for fiber and fabric developments that could be advanced if this threat should grow. Limited protection is available in the NYCO (nylon-cotton blend) fabric now used in the cold weather clothing coat and trousers. Beyond this, new or modified fibers would be required, with the need to create new fiber manufacturing capacity.

10. Personal Equipment

The term "personal equipment of the soldier" is used most frequently to refer to the items of the soldier's load-carrying equipment — his pack, shoulder harness, entrenching tool, canteen, first aid packet, etc. In the past, this equipment was made from cotton duck and webbing. In 1967, this entire set of equipment was converted to nylon, which reduced the weight when dry from 5.15 pounds to 3.3 pounds. In place of Type IIA cotton webbings, which were stiff enough to hold in the buckles then used, lightweight nylon tapes were substituted and the buckles, snaps and other fasteners were redesigned to hold these nylon tapes properly.

Recently an entire redesign of the whole load-carrying system has been completed, again utilizing only nylon materials. The principal fabric weighs only 7¼ oz/yd^2 and the straps are all made of lightweight nylon tapes. As a result, the requirement for cotton duck and cotton webbing for this type of equipment no longer exists, having been replaced by filament nylon. However, it must be noted that, while heavy cotton ducks will no longer be required for the soldier's equipment, there will continue to be a critical requirement for narrow fabric weaving capacity to produce webbings of both man-made fibers and cotton in various sizes and weights. The problem of assuring adequate industry capacity to produce these narrow fabrics will be dealt with later in this study.

The technical requirements for this system can be listed as follows:

TABLE A-11
TECHNICAL REQUIREMENTS FOR TEXTILES
USED IN THE PERSONAL EQUIPMENT OF THE SOLDIER

Critical

— Light weight

Essential

— Water vapor permeable (fabrics)
— Water repellent (fabrics)
— Tightly woven (fabrics)
— Slip resistant (webbings)
— Abrasion resistant
— Tear resistant
— Low water pick-up
— Fire resistant
— Mildew resistant
— Dyeable to fast camouflage colors

Desirable

— Easy to clean and decontaminate
— Melt resistant
— Good appearance

The critical requirement assigned to lightness in weight is in keeping with the overall need to hold down the load of the soldier. This has been a major concern of the Army at all times, but has been given greatly increased emphasis during the Vietnam war because of the dominant role played by the individual soldier in much of the action, and the need for him to carry with him a large part of his supplies. From this arose the LINCLOE Program (Lightweight INdividual CLothing and Equipment) under which a major development program has been underway to reduce everything the soldier may be called upon to wear or carry. By general agreement, the load should not exceed a third of body weight, which for the average soldier weighing 154 pounds would amount to not more than 51 pounds. However, the load carried by the infantry rifleman in hot weather areas actually weighs 61.2 pounds with an added weight of 43.24 pounds for extreme cold areas. This gives a total load in extreme cold areas of 104.15 pounds, and for cold weather areas (cold-wet) of 90.59 pounds, exclusive of the weight of skis or snowshoes.

In addition, there are many other pieces of equipment which must be carried by some men in the infantry company. For example, the radio-telephone operator must carry an added weight of 28.55 pounds. Then there are the members of the mortar platoon, the weapons squad, etc. who have special loads pertaining to the mission of their weapons. (For a fuller discussion of the problem of the load of the soldier, see: The Carrying of Loads Within the Infantry Company, by S. J. Kennedy, Ralph F. Goldman, and John Slauta, U. S. Army Natick Laboratories, Natick, Mass., 1973.)

It will be evident that an aggressive, continuing program to apply advances in materials technology to reduce the weight of all items carried by the soldier, in keeping with the LINCLOE concept, should continue to have priority consideration both within Army research and development and within the industry.

The textiles currently being used in the major items of general issue personal equipment are listed in Table A-12.

TABLE A-12

TEXTILES USED IN GENERAL ISSUE PERSONAL EQUIPMENT

Item	No. Issued	Fabrics Used	Sq. Yds. per 1000 men
Bag, barracks	1	Cloth, cotton, sateen	3004
Bag, duffle	1	Cloth, cotton, duck No. 8	477
		No. 10	2092
Blanket, bed, wool	2	Cloth, wool	4485
Shelter half	1	Cloth, duck, cotton/rayon	7273
Towel, bath	2	Cloth, terry	1526
Belt, Individual Equip.	1	Webbing, nylon 2¼" Type III	
Case, First Aid dressing	1	Cloth, nylon	36
Case, small arms, ammo	2	Cloth, nylon	818
Cover, water canteen	1	Cloth, nylon	240
		Cloth, pile, acrylic	141
Field Pack, medium	1	Cloth, duck, nylon 7¼ oz.	3584
		Cloth, duck, nylon 12.5 oz.	170
		Cloth, nylon, vinyl coated	131
		Cloth, spacer, olefin	200
Suspender, Field Pack	1	Cloth, nylon	109
		Cloth, spacer, olefin	72
	Total, above items		21,438
OPTIONAL PACK			
Field Pack, large	1	Cloth, duck, nylon 7¼ oz.	4138
		Cloth, duck, nylon 12.5 oz.	170
		Cloth, nylon, vinyl coated	215
		Cloth, spacer, olefin	200
			4723

11. Camouflage of the Individual Soldier

The requirement for dyeing of military textiles with fast camouflage colors involves both the ability of the textile fibers and fabrics to accept dye to achieve the desired shade with reasonably close shade matching, and the availability of dyes having the desired spectral characteristics.

During World War II, when the need to provide an adequate supply of dyes for military textiles created serious problems for the dyestuff industry, the problem was one simply of meeting requirements for camouflage coloration against visual observation. Today, the requirement for camouflage of the individual soldier calls for the following kinds of protection against battlefield surveillance:

- Against visual observation with the naked eye,
- The same with binoculars, with or without filters,
- Against infra-red viewing devices, e.g., the sniperscope,
- Against IR photography,
- Against image intensifiers, particularly at night,
- Against radar,
- Against thermal sensors of body heat

Since the dyes which will be relied upon to provide much of this camouflage (except radar and thermal emission) will be different from those used in large quantities in the civilian consumer market for textiles, the availability of an adequate supply of dyes of proper color and spectral characteristics at the time of mobilization constitutes a special problem that must be addressed separately from the matter of textile fiber and textile fabric manufacturing capabilities.

12. Tents

The need for tents constitutes perhaps the biggest and most difficult problem which the textile industry must be prepared to face in the event of mobilization. The reason for this will be evident from the technical requirements for tentage fabrics.

TABLE A-13

TECHNICAL REQUIREMENTS FOR TENT FABRICS

Critical	
— Fire resistant	Inherent, or with additive finish, or both.
— Water resistant	To one inch/hr for 12 hours, plus 3 inches per hour for 2 hrs.
— Resistant to Solar Degradation	To retain serviceability for at least 12 months continuous exposure in the tropics.
— Mildew resistant	As above for Solar Degradation
— Wind resistant	Shall resist the passage of air greater than 5 $ft^3/min/ft^2$ at 0.5" water pressure with 1 to 2 ft^3 desirable.
Essential	
— Water vapor permeable	Able to pass moisture at rates not less than 25 grams/sq meter/hr at 70^oF and 55% RH.
— Tear resistant	Not less than 6 x 6 lbs/Elmendorf
— Low water pick-up	Dynamic absorption of less than 15%
— Breaking strength	Able to take snow loads of 10 lbs/sq ft and wind loads up to 80 miles/hr.
— Flexible at all temperatures	Shall not interfere with pitching, striking and packaging characteristics.
— Colorable to camouflage	Against visual observation and camouflage detection film
— Lightproof	To preclude detection of light beyond 100 meters for 2-cell flashlight held one foot from the wall with beam directed toward the ground.
Desirable	
— Light Weight	Fabric sufficient to cover 100 sq ft of floor space shall weigh no more than 40 lbs. - to permit man-packing.
— Abrasion resistant	Shall resist snags and wear when dragged over the ground in end item form.
— Non-toxic	Shall not cause dermatitis in handling.

Fire resistance of tents and thus of tentage materials must be regarded as a critical requirement. This applies irrespective of whether the tent is used to house personnel or to shelter supplies. Further, there is no possibility of eliminating or modifying this requirement. This was true in World War II, long before the Flammable Fabrics Act was developed, and is still applicable today.

Fire resistance in tentage fabrics involves a different dimension than is usually attributed to the term with its attendant properties of resistance to afterflame, resistance to afterglow, and limited destruction due to char. Fire resistance for tentage means, in this instance, that the fabric when incorporated into pin-a[illegible]pole tentage or perhaps a frame-supported tent, or when used in a paulin,will be self-extinguishing when subjected to a fire condition similar to that encountered by the tent during use. The fire must not be self propagating, and damage to the tent must be limited to that sustained during application of the test flame. Afterglow is not required to be self-extinguishing for it does not pose a serious hazard to personnel occupying tents.

The fire conditions considered likely to be encountered in a tent are of two types. The first type of fire, originating inside the tent, can be simulated by placing two pounds of shredded newspaper in a wire wastebasket and igniting it after placing it within the tent next to a sidewall and preferably in a corner. In this simulated test, the door is closed, and the results observed from outside the tent. The second type of fire condition arises from an exterior fire such as would occur to a tent surrounded by high, dry grass, or where poor housekeeping has allowed the accumulation of combustibles outside the tent next to the sidewall. These conditions can be simulated by distributing shredded newspaper for six feet from the corner of the tent on its lee side. The paper is distributed at a loading of one pound per linear foot and ignited.

Numerous tests conducted with tents under such fire conditions have shown that many fabrics which appear to be fire resistant according to standard laboratory tests will burn when made up into model tents. Conversely, single wall, air-supported shelters have been shown not to burn even when made of non-fire resistant materials. This situation is due in part to the fact that laboratory tests do not enhance the entrapment of gases evolved during early decomposition of the tent fabric. Rather, the fabric is subject to flame attack and the gases evolved escape from both fabric surfaces. In the case of single wall- air-supported tent material, the tent itself carries its own built-in fire extinguisher in that any flame induced on the fabric is rapidly cooled and extinguished by the rush of air when flame penetrates the wall.

The requirements for a fabric with or without a treatment, that will cause a flame to be self-extinguishing under the conditions of a pitched tent are very severe. They have

been met up to now by three materials:

a. Cotton fabrics treated with Fire, Water, and Mildew Resistant Finish covered by specification MIL-C-41808B and CCC-C-428d.

b. A tightly woven, fine textured cotton sateen fabric, finished with vinyl-chloride-antimony oxide modification of THPC under specification MIL-C-12095.

c. A 10 oz. plain weave fabric made from a specific modacrylic fiber fabric as produced under specification LP/P DES.48-68.

All of the above treatments or fibers release halogens which serve to suppress the ignitibility of decomposition products as well as modifying the decomposition of the fibrous substrate. Both factors are needed to control fire in a tent.

As noted above, acceptable fire resistance in tents has been realized using modacrylic fiber fabric, specifically Dynel. Here, the mechanism of decomposition tends to cause physical movement of the fabric away from the flame during its decomposition, or depolymerization from the heat of the applied flame. Further, in its decomposition, chlorine is released from the vinylidene co-polymer of the modacrylic and this suppresses the ignition of flammable volatile decomposition products. The practicability of producing on a production scale the modacrylic fiber as a substitute for FWWMR coated duck for tents, which has the required high degree of tightness to provide low air permeability, has yet to be determined, since tent fabrics of this type have been produced only on a small scale for limited tests.

The experience of the military services in obtaining their requirements for fire resistant tentage fabrics in the three wars covered in this report are dealt with elsewhere in this report. It should be noted, however, that coordinated effort by three industries is involved: textile weavers for the fabric; dyers and finishers for application of the special finishes involved; and the chemical industry for the special fibers and chemical compounds needed.

In addition to fire resistance, tent fabrics must be water resistant. The requirement of one inch per hour for twelve hours and three inches per hour for two hours are not consistent with actual environmental requirements. At this time, only water repellent treated cellulosic type water vapor permeable fabrics, which swell when wetted out, can meet this requirement. Coated fabrics are undesirable in pin-and-pole supported tents as they do not allow the escape of atmospheric moisture, and thereby cause condensation on the inside of the tent. In single wall, air-supported structures, the constant, fan-driven incoming air and normal leakage prevents condensation from becoming a problem. In double wall, air-supported structures, the air between the double walls acts as an insulator and reduces this problem of internal condensation.

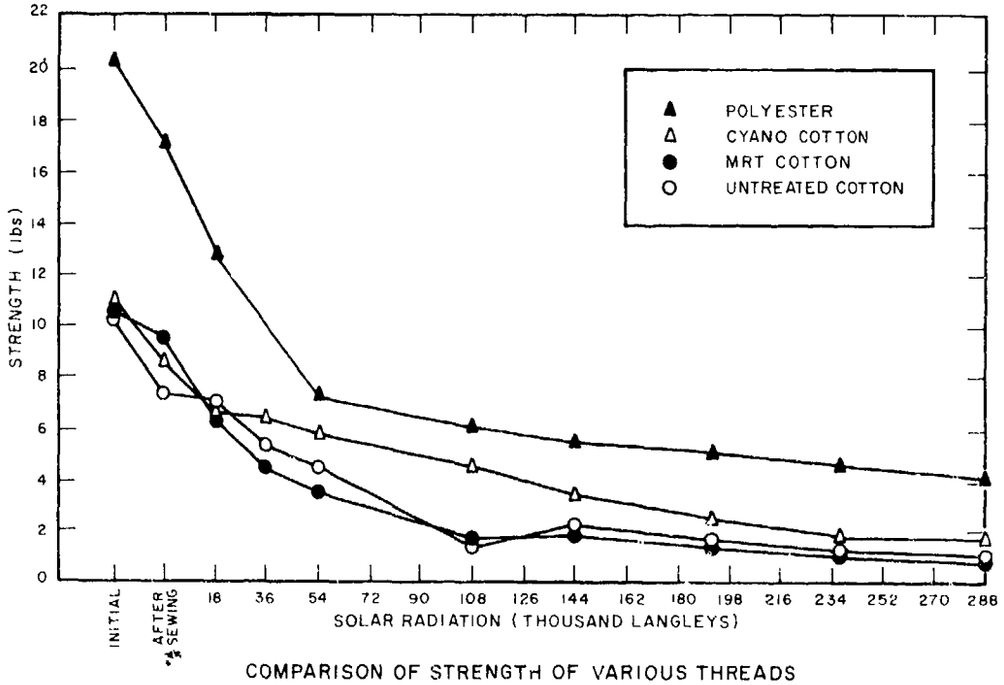
Resistance to solar degradation and to weathering generally is critical in a tent fabric. The rate of degradation, which directly depends upon the vulnerability of the fiber molecule

to the effects of certain bands of the spectrum, particularly ultra-violet, is also related to the mass of fibers, i.e., the outer layers tend to protect the fiber underneath. Hence, a heavier and thicker fabric is less vulnerable to solar degradation than a thinner fabric, more than proportionate to the difference in thickness. Hence the desire for lighter weight tent fabrics is diametrically opposed to the requirement for long service life — the lighter the weight, the shorter may be the anticipated life of the tent.

One action which has reduced the problem of leakage due to stretching of the duck fabric when the tent is pitched was the adoption some years ago of a low-elongation webbing as the stress bearing member of the tent deck, so that the tent duck fabric would be relieved of stress. This webbing utilizes a high modular fiber in the stuffer yarns which could be held to elongation under 2% even under heavy loads. This has permitted the use of a lighter weight fabric for the tent deck.

Actually, the Fire, Water, Weather, and Mildew Resistant Treatment which has been used on military tent fabrics is an excellent multi-purpose finish and has not been equalled by any other combination of fibers and/or finishes.

The fabrics and webbings used in tents are shown in Table A-14. It will be noted that the basic fabric is the 9.85 oz. duck, made from two-ply warp and filling yarns. This fabric reconstructed several years ago to have balanced warp and filling strength is considered to be of minimum strength and thickness to withstand weathering, and to meet the other critical requirements of a tent fabric in accordance with present technology. Also, it should be noted that the Tent, General Purpose, Medium, is the largest volume tent, used for most purposes, particularly for personnel housing, as well as other miscellaneous uses.



COMPARISON OF STRENGTH OF VARIOUS THREADS
AFTER EXPOSURE TO WEATHERING

TABLE A-14

TEXTILES USED IN TENTS

Item	Fabrics Used	Sq Yds per Tent
Tent, Hexagonal, Lt.Wt.	Cloth, cotton, WR Sateen, FR	54.0
	Cloth, cotton, duck, 9.85 oz.	.5
	Webbing, low elongation, 1"	76.0
	Other webbings	10.0
	Tapes, cotton	9.0
	Tapes, nylon	24.3
Tent, arctic, 10-man	Cloth, cotton, WR Sateen, FR	90.4
	Cloth, cotton, duck, 9.85 oz.	.2
	Tapes, cotton	98.8
	Webbing, low elongation, 1"	107.1
	Cloth, netting, nylon	11.3
Tent, General Purpose, small	Cloth, cotton, duck, 9.85 oz. FR	106.4
	Cloth, nylon, netting	19.3
	Webbing, low elongation, 1"	130.6
	Tapes, cotton	74.3
	Tapes, nylon	43.8
Tent, Command Post	Cloth, cotton, duck, 9.85 oz. FR	127.4
	Webbing, low elongation 1½"	24.1
	Tapes, cotton	63.9
Tent, Kitchen, flyproof	Cloth, cotton, duck, 9.85 oz.	201.3
	Webbing, low elongation 1½"	34.4
	Tapes, cotton	264.2
Tent, General Purpose, medium	Cloth, cotton, duck, 9.85 oz.	268.2
	Webbing, low elongation 1½"	131.4
	Tapes, cotton	90.5
Tent, General Purpose, large	Cloth, cotton duck, 9.85 oz.	423.4
	Webbing, low elongation 1½"	175.1
	Tapes, cotton	196.8
Tent Assembly	Cloth, cotton, duck, 12.29 oz.	565.5
	Cloth, cotton, duck, 9.85 oz.	311.0
	Webbing, cotton	115.0
Tent, frame type 16 x 16	Cloth, cotton, WR Sateen FR	162.2
	Webbing, low elongation 1"	10.5
	Tapes, cotton	126.6
Tent, frame type, insulated 16" section, complete	Cloth, vinyl coated duck, 9.85 oz.	145.9
	Webbings, cotton	97.9
	Tapes, cotton	16.0

TABLE A-14
(Continued)

Item	Fabrics Used	Sq Yds per Tent
Tent, maintenance shelter	Cloth, cotton, duck, 9.85 oz.	313.4
	Cloth, cotton duck No. 6	13.2
Tent,frame type, maintenance sections, medium	Cloth, cotton, duck 0.95 oz.	143.3
	Tapes, cotton	24.5
	Webbings, cotton	13.2
Tent, radome, air supported	Cloth, polyester	257.0
	Webbing, nylon	21.3
Tent, double wall, air supported Nike Hercules system	Cloth, coated nylon	3108.0
	Tapes, cotton	100.1
	Webbings, cotton	9.3
	Webbings, nylon	114.4
TENT LINERS		
Tent, hexagonal, Lt.Wt.	Cloth, cotton sheeting	35.8
	Webbings, cotton	43.7
Tent, general purpose, small	Cloth, cotton, permeable, 5.2 oz.	66.4
	Webbing, low elongation 1"	63.2
	Tapes	14.4
Liner, tent, general purpose medium	Cloth, cotton oxford 5.2 oz.	162.4
	Cloth, saran, netting	45.4
	Webbing, low elongation 1"	102.7
	Webbings, other cotton	89.0
Liner, tent, general purpose large	Cloth, cotton oxford, 5.2 oz.	281.3
	Cloth, saran, netting	71.9
	Webbing, low elongation 1"	123.5
	Webbing, other cotton	119.7
Liner, section, tent, frame-type, maintenance	Cloth, cotton sateen	549.4
	Tapes, cotton	105.3

II. PARACHUTES AND RELATED AIR-DROP EQUIPMENT

Personnel parachutes are identified as "safety of personnel" items, and the tie-downs and extraction chutes of cargo parachutes are classified as "safety of aircraft" items. As such these items are covered by unusually stringent design and safety specifications, manufacturing practices, quality assurance procedures and handling, and storage and surveillance requirements. The technical requirements applicable to the various textiles used in parachutes and air-drop equipment are shown in Table A-15.

TABLE A-15

TECHNICAL REQUIREMENTS FOR TEXTILES
FOR PARACHUTES AND RELATED AIR-DROP EQUIPMENT

Requirements	Canopies	Canopy Lines	Harnesses	Extraction Lines	Tie-Downs	Suspension Slings	Deployment Bags Packs
Light Weight	Desirable	Desirable	Desirable	Critical	Desirable	Desirable	Desirable
High Impact Strength	Critical	Critical	Critical	Critical	Critical	Critical	Desirable
Low Bulk	Essential	Essential	Essential	Critical	Desirable	Essential	Desirable
Abrasion Resistant	Essential	Essential	Essential	Critical	Critical	Critical	Essential
Light & Heat Resistant	Essential	Essential	Essential	Essential	Essential	Essential	Essential
Melt Resistant	Essential	Essential	Desirable	Desirable	Desirable	Essential	Desirable

Other special requirements include controlled air porosity for canopy fabrics, within a specified range to assure proper opening characteristics.

For cargo parachutes, for use in re-supply operations where no recovery is normally feasible, cost is a critical requirement which impacts heavily on the technical requirements. Technical requirements may have to be "traded-off" against cost for "one-time use" parachutes.

For certain load tie-downs, low elongation is an essential requirement. For example, for normal tie-down of loads to air-drop platforms, polyester rather than nylon is being used because of its lower elongation and less susceptibility to load shift. For the LAPES air-drop system, nylon is being used because of the higher "g" forces involved.

Another important requirement is for repair and replacement parts. In view of the high maintenance requirements for parachutes, parts which may have been damaged or are of questionable serviceability, must be replaced in normal repair operations.

TABLE A-16

PRINCIPAL TYPES OF PARACHUTES

Parachute	Type Cloth
Parachute, Personnel T-10 Back 1670-753-3727	MIL-C-7020F, Type I
Parachute, Personnel T-10 Reserve 1670-376-8779	MIL-C-7020F, Type I
Parachute, Personnel MC1-1 1670-182-3220	MIL-C-7020F, Type I
Pilot Chute, Personnel Back 1670-892-4215	MIL-C-7020F, Type I
Parachute, Halo, Back 1670-892-4215	MIL-C-7020F, Type I
Parachute, Cargo, 500 lb. Cap. 12 ft. high velocity 1670-999=2658	MIL-C-4279, Type III (cotton)
Parachute, Cargo, 500 lb. Cap. 12 ft. high velocity 1670-788-8666	MIL-C-4279, Type III (cotton)
Parachute, Cargo, 2200 lb. Cap. 26 ft, High Velocity 1670-872-6109	MIL-C-4279, Type III (cotton)
Parachute, Cargo, 2200 lb. Cap. 64 ft, Type G-11A —1670-893-2371	MIL-C-7350, Type I (nylon)
Parachute, Cargo, 3500 lb. Cap. 100 ft. Type G-11A —1670-269-1107	MIL-C-7020F, Type II (nylon)

TABLE A-16 (Continued)

Parachute	Type Cloth
Parachute, Extraction 15 ft., 1670-052-1548	MIL-C-7350, Type I
Parachute, Extraction 22 foot, 1670-687-5458	MIL-C-7350, Type II
Parachute, Extraction 28 foot, 1670-687-5458	MIL-C-7350, Type II (Nylon)
Pilot Chute, G-12 1670-216-7297	MIL-C-7020F, Type I

APPENDIX B

FEDERAL SPECIFICATION CLASSES
IN WHICH TEXTILES OR ITEMS USING TEXTILES ARE LISTED

FSC CLASS

3510	—	Laundry & Dry cleaning equipment
4020	—	Fiber Rope, Cordage, & Twine
5970	—	Electrical Insulators & Insulating Materials
6532	—	Hospital & Surgical Clothing & Textile Specific Purpose Items
7210	—	Household Furnishings
7220	—	Floor Coverings
7290	—	Miscellaneous Household & Commercial Furnishings & Appliances
7920	—	Brooms, Brushes, Mops & Sponges
8305	—	Textile Fabrics
8310	—	Yarn & Thread
8315	—	Notions & Apparel Findings
8320	—	Padding & Stuffing Materials
8325	—	Fur Materials
8335	—	Shoe Findings & Soling Materials
8340	—	Tents & Tarpaulins
8405	—	Outerwear, Men's
8410	—	Outerwear, Women's
8415	—	Clothing, Special Purpose
8420	—	Underwear & Nightwear, Men's
8430	—	Footwear, Men's
8435	—	Footwear, Women's
8440	—	Hosiery, Handwear, & Clothing Accessories, Men's
8445	—	Hosiery, Handwear, & Clothing Accessories, Women's
8465	—	Individual Equipment
8470	—	Armor, Personal
9420	—	Fibers, Vegetable, Animal & Synthetic
9925	—	Ecclesiastical Equipment, Furnishings, & Supplies
9930	—	Memorials, Cemeterial, & Mortuary Equipment & Supplies

APPENDIX C

COMMENTS OF THE COTTON AND TEXTILE DEFENSE CAPABILITY COMMITTEE

Conclusion No. 1 : The production base of the textile industry can no longer be considered to be relatively static. Where long term planning is concerned, it must be recognized that mills making a particular product in one year may, in response to market changes, no longer be making that product, or be able to make it, even only a year or two later.

Comment: The Committee agrees that significant changes have occurred in the production base of the industry, notably the widespread use of synthetic fibers and rapid growth in the knitting and tufting industries. Additionally, wider and faster looms in place today produce roughly the same quantity of fabric that the 400,000 broad weaving units did during the years 1950-1965. As population increases and the opportunities for export increase, there will probably be a yearly gain both in weaving and knitting capacity. With knitted fabrics established as a viable apparel for outerwear, substitutions can be made in the civilian sector to permit broad weaving capabilities to be turned to national defense needs. However, the industry continues to change, as exemplified by the recent trend toward open-end spinning. The Committee recommends periodic evaluation by the Department of Defense to determine the industry's ability to meet DOD requirements.

Conclusion No. 2 : Since the functional performance requirements for military textiles essentially limit them at this time to broadwoven goods, the future of this segment of the textile industry is a matter of major concern to national defense.

Comment: The Committee concurs in the critical dependence of the military on broadwoven goods.

Conclusion No. 3 : Production of broadwoven goods has not been rising in recent years proportionate to the growth of consumer demand for textiles, nor is it likely, in the near future, to be an attractive area for investment of new capital for significant expansion. Imports, which can be expected to continue to expand beyond the present 15% of the market although at a somewhat reduced rate, and competition from knitted fabrics, constitute limiting factors on growth of broadwoven goods production.

Comment: The Committee concurs that broadwoven goods production has not been proportionate to growth in consumer demand for textiles. Excessive imports of such goods should be avoided through proper administration of textile trade agreements. Also, the Committee recommends more rapid amortization of weaving machinery as well as other types of textile plant and equipment.

Conclusion No. 4 : Some of the segments of the broadwoven goods industry of most direct importance for military textiles are quite limited in capacity, particularly duck, fine combed cotton goods and worsteds, and are in a downward trend.

Comment: The Committee concurs in the limited capacity available for the production of broadwoven duck, fine combed cotton, and worsteds. The situation, in 1975, is as predicted, and there is no sign of reversal in the trend.

Conclusion No. 5 : The trend in the textile industry and the U.S. textile market toward increased use of the non-cellulosic man-made fibers, either in blend with the natural fibers or as replacements for them, will necessitate some redevelopment of present military textiles in order to keep sources of supply available.

Comment: The Committee concurs and notes that the Army Materiel Command (and other services as well) have initiated a number of programs to explore the immediate application of polyester/wool and polyester/cotton blends for military use.

Conclusion No. 6 : From the standpoint of national security, too great a commitment to the man-made fibers should be regarded with caution when regarded from the standpoint of the time frame projected in this study, 1980-85. The balance of trade deficit in energy fuels which can be anticipated by that date could have serious consequences upon the military, political and economic security of the United States, since our country would become increasingly dependent on the political and economic security of a relatively small number of countries in the Middle East. Under these conditions, it would appear to be a prudent course of action for the military to be prepared for the use of alternate textile fibers, the supply of which would not be dependent upon oil or gas, and which would require the minimum amount of energy for their conversion into military textiles. This would indicate the desirability for the military services to be able in such an emergency to obtain quickly large quantities of military textiles made from cotton and wool. From this standpoint, the maintenance of textile manufacturing facilities capable of producing textiles from cotton, and the continued use of textiles predominantly made from cotton by the military, would appear to be in the interests of national security.

Comment: The Committee concurs that national security should not become dependent on the political and economic policies of any small group of countries that can significantly limit our use of energy fuels or fibers. Alternative fiber sources should be available for military use. Long term procurement policies of the Defense Department should recognize the importance to national security of quickly available stocks of those fibers essential to defense mobilization.

Conclusion No. 7 : The present policy of the military services with respect to the use of cotton should be continued. It should be supported by positive actions by appropriate government authorities to (a) minimize the fluctuations in the price of cotton which adversely affect its desirability to textile manufacturers; (b) - assure a carry-over of adequate size to meet possible military needs as to quantity, grade and staple at any time in the crop year.

Comment: The Committee agrees that cotton fiber needs to be available for defense mobilization purposes. Cotton tends to lose markets when prices fluctuate widely. Therefore, a continuous adequate supply is needed to assist in stabilizing the price of cotton. Adequate cotton carryover is essential as a part of thissupply, not only to meet military mobilization requirements, but also to prevent temporary shortages of raw cotton and inordinately wide fluctuations in price causing too much or too little production. To assist in price stabilization for cotton, and to effectuate Department of Defense cost savings, the Committee recommends (a) increased Defense Department purchases of cotton textiles during periods of textile and economic recession? (b) adequate stocks of cotton textiles such as apparel, duck for tenting. and other textiles essential to mobilization should be carried as reserve stocks to make it possible for the Defense Department to, not only meet mobilization requirements, but also to facilitate the textile industry's ability to serve the civilian population.

Conclusion No. 8 : The lack of a potential reserve of labor in the major textile manufacturing areas which could well continue or intensify over the next several years, could pose a serious problem to achieving a high level of output on military textiles quickly in the event of mobilization.

Comment: The Committee concurs that available reserves or surpluses of labor are no longer plentiful in textile producing areas. However, methods of accelerated in=plant training of operating personnel have improved. It does not appear to be practical to "stockpile" trained labor reserves outside the industry. The Committee recommends that recognition and priorities be given to employment in critical textiles jobs in mobilization planning. The Department of Defense should consider ways and means of providing official recognition and opportunities for military personnel trained in the textile area, as well as a planned program for interchange between military and industrial textile counterparts.

Conclusion No. 9 : Lack of a broad-based textile machinery industry within the United States, with so large a proportion of presently installed mill equipment having been made overseas, could create a serious spare parts problem in a crisis situation. Loss of production capacity during the early part of the period while domestic manufacturers tooled up to produce needed parts for foreign equipment could seriously limit the capability of the industry to reach high production levels quickly.

Comment: The Committee recognizes possible difficulties in obtaining spare parts. However, in the last few years a trend toward more foreign machinery manufacturers

Comment: (Continued) setting up manufacturing, assembly and/or spare parts warehousing has developed. Certain items might be found to be in short supply for a period of time, but a number of small companies have responded to the need for upgrading equipment since World War II. An estimated 400 firms ranging from machine shop types to rather sizable manufacturing installations to supply parts now exist to service the textile industry. The majority of looms making broadwoven goods are American made.

Conclusion No 10: The industries which convert textiles into the end items used by troops: parachutes, protective combat clothing, uniforms, equipment, personnel armor, etc., can be expected to lose contact with military items during a prolonged period of peace. They may accordingly be ill-prepared to move quickly into production of military items in an emergency. Some industries which produce almost entirely for the military, such as those making parachutes, personnel armor, and large tents, may be so reduced in size as to be quite inadequate as a production base from which to provide large scale production.

Comment: The Committee concurs and recommends that the services reevaluate the the extent to which programs in manufacturing technology are keeping current. The Committee specifically notes the validity of this conclusion with respect to many items having only military application, and need for a reexamination of this area in the light of the recent economic pressures upon the industry.

Conclusion 11: (A) A broad-based research and development program to develop alternate textile materials which will be in consonance with industry's capabilities for large scale production within the projected time frame, 1980-1985, and yet which will meet all critical and essential technical requirements, should be undertaken as a matter of priority.

(B) In view of the rapid changes taking place in the industry on the one hand, and the need for prudent reserve about too great a commitment to man-made fibers based upon oil, of which a large part will have to be imported in the time frame suggested, such a research and development program should proceed along several lines simultaneously, including especially the upgrading of the performance of cotton textiles or limited mixtures of other fibers with cotton. The support of industry and the U.S. Department of Agriculture should be obtained on as broad a base as possible to assure the availability of materials conforming to all military needs.

Comment: The Committee whole-heartedly endorses the foregoing. For a variety of reasons, some of which are peculiar to the industry segment involved, the research and development support in the clothing and textile area has been inadequate to keep pace with the military's needs. The Committee also

Comment: (Continued)

notes that this problem is compounded by the many recent technological changes in the industry, and the unique requirements of military textiles that prohibit ready interchange with items acceptable to the civilian sector. To resolve this, the Committee recommends support of a research and development program, managed by the Army, as further outlined in the Proposed Research and Development Program (attached). In preparing this recommended program, the Committee notes that it offers the potential of not only alleviating future mobilization problems, but of improving the technological posture of the industry with subsequent advantages to the economy. The Committee also notes that within the Department of Defense, the pressures of many high priority programs frequently leave little emphasis on clothing and textile research. Inasmuch as the DOD procures clothing and textile items to the extent of approximately $500,000,000 per year, the Committee recommends that the research and development in this area be assigned a higher priority, commensurate with the mobilization problem noted, and the concomitant beneficial effects to the economy.

Conclusion 12 :

The complexity of the textile and related industries and their unlikeness to the hard goods industries which has baffled and frustrated so many military personnel who have not had previous relation to these industries, would indicate that the need for a commodity training program, such as a graduate program in textiles at university level for officers who are to be assigned in the fields of procurement, supply or administration in this area. The success of the World War II Quartermaster textile and clothing operation was due largely to the fact that practically all officers involved in it were drawn from the textile and clothing industries. The availability of officers with such training in the future will be essential to effective operation of a future mobilization program.

Comment:

The Committee concurs, and directs the attention of the services to the recommendation. At the same time, it acknowledges the efforts of the services mobilization reserve programs, which are intended to satisfy this requirement.

Conclusion 13 :

(A) With respect to the first of the two parts of the basic question raised in this study, viz., the availability of a broad industry base to supply needed military textiles in large quantities quickly upon mobilization, it is clear that at present such a broad base does not exist for duck, fine combed cotton goods, or worsted uniform fabrics. Also, because of the special manufacturing equipment required to make these fabrics, very little conversion of other mills' capacity could be turned into producing them. Alternate materials are needed as either partial or total replacements for these materials.

Conclusion 13 : (Continued)

(B) But even for total textile needs, there can be serious questions whether conversion of the industry could be accomplished quickly enough, together with that of the industries which would have to convert textiles into the end items used by troops, to bring production up to usage rate by the end of the year, if large scale mobilization were necessary. As shown in this study, there are numerous unfavorable factors which could delay attainment of a required high level of production quickly. The repetition of what occurred during the Korean War, when quantity production could not be attained until the second year of the war, should be recognized as a potential hazard.

Comment:

The Committee believes that the research and development program recommended (see Conclusion 11) will, if properly supported, provide answers to the foregoing technological problems. However, the Committee notes that a significant portion of the problem occurring during the Korea mobilization was (during the most critical period, the first 90 days) not problems of a production nature, but delays in initiating production contracts. Accordingly, the Committee commends the report to the attention of DSA in this regard.

Conclusion 14 :

As to the other aspect of whether, if the conflict were prolonged, the industry base would be adequate to meet the needs both of the military and the civilian population, the answer is clearly negative. With a large segment of the total civilian demand now being met by imports, which can be expected to increase in coming years, the demands for military textiles would so limit the amount available to consumers that, with imports shut off, severe limitations upon civilian usage would be required. The resulting morale aspects and the problems of price controls, black markets, etc., could be serious as was demonstrated during World War II, where the supply situation was far less critical than it would be in the future or even today.

Comment:

The Committee feels that the primary concern of the report, with which it concurs, deals with problems that would be encountered during mobilization. The longer term problems of a sustained conflict are likely to find solution in the research and development program proposed and therefore do not warrant further consideration at this time. This is not to say that the problem identified can be ignored; it should be a matter of continuing assessment as the proposed research and development program proceeds.

PROPOSED RESEARCH AND DEVELOPMENT PROGRAM

Introduction:

This proposed research and development program has been outlined in response to the Committee's reaction to conclusions enumerated in the U.S. Army Materiel Command's Technical Report 73-50-CE, the Kennedy report, on the changing capability of the textile industry to support national defense. The report recommends a broad-based research and development program to evaluate the production base of the textile industry and its capabilities to meet all critical and essential technical requirements for mobilization.

Support:

Recognizing that the Department of Defense procures in excess of 500 million dollars a year in clothing and textile items, the program proposed at a rate of 20 million dollars a year is modest by any industry standards. More important, it must be recognized that the economic conditions in the clothing and textile industry today do not permit the support of any aggressive research and development effort, nor have they in recent years. For this reason, the support of this program will not only alleviate the problems of mobilization outlined in the report, but it will provide a significant assist to the industry as previously noted.

The proposed budget requirement of $20 million recognizes the importance of the textile mobilization problem and the magnitude of the effort needed to undertake necessary research and development. It is not feasible to itemize the costs of the several research proposals separately, until priorities are set and changing regulations imposed by the Environmental Protection Agency, the Occupational Safety and Health Administration or other requirements are identified as related to each.

Approach:

As indicated above, the research and development program proposed addresses itself to a variety of needs, ranging from basic research in textile technology through the manufacturing technology required to meet the needs outlined in subject report. The program proposed would provide a powerful stimulus to upgrade the technology of the industry and thus the nation's ability to not only meet its anticipated mobilization needs, but also the competition from other nations which has eroded the U.S. position in textile technology. In addition to the pressures of a rapidly changing technology and the foreign competition, the problems created by environmental and safety statutues further accentuate the need for accelerated and expanded research in the area of clothing and textile technology.

Because the primary need to be served by this research and development program is to alleviate an existing problem faced by the Department of Defense, it is proposed that the overall program be managed by the U.S. Army Natick Research & Development Command, which currently performs the major portion of research in this area within the Department of Defense. It is also recognized that significant portions of the research

proposed can be effectively performed by other Federal Agencies, by industry, and by educational institutions. The Army Natick R&D Command, in managing this program, will be responsible for drawing on such organizations in order to maximize the use of the nation's resources in this area.

Scope:

The research and development program proposed comprises effort which can be identified in nine areas for planning purposes.

1. A study of chemical, textile and agricultural industries as they relate to clothing and textile needs for the Department of Defense.

This effort which would comprise a study of the combined effects of economic, environmental, and safety aspects (as well as potential materials shortages) on a long-term availability of cotton, wool or other items required to satisfy military needs, is a critically needed first step. Although this is not a typical research and development effort, the results of this study would guide the research effort in other areas of the program. As noted in Dr. Kennedy's report, there is considerable evidence of economic, technical, energy, and other factors that would influence materials available for mobilization. Research and product development is needed to provide fibers and products to meet military needs in the years ahead.

2. Evaluation of manufacturing equipment, production rates and spare parts problems in the textile industry.

This portion of the program would not only provide accurate assessment of such problems as the availability of spare parts for foreign-produced equipment in the event of mobilization, but would also address itself to means for obtaining the greatest flexibility and producibility from existing equipment to satisfy military needs in the event of mobilization. The effort would specifically include an investigation of means to increase productivity on existing or modified equipment. Open-end spinning is an example of one. Another is the shortage of spindles available to produce lightweight and absorbent fine count cotton yarns needed for mobilization.

3. Evaluation of capabilities of the dyeing and finishing industry with respect to material shortages and other restraints such as safety and environmental.

This segment of the industry is singled out for special attention because it is most severely impacted by the foregoing restraints. The effort would not only involve complete assessment of the long-term ability of the industry to provide resources for mobilization but would also include research and development effort directed to alleviate the specific problems identified. For example, the availability of natural gas is critical in textile finishing plants where an intense, clean open heat is necessary.

4. A study of "sheet" materials required to fulfill the needs of the Department of Defense.

Many Department of Defense applications which now depend heavily upon such materials as broadwoven goods constitute potential shortage problems in the event of

mobilization because of the declining trend in such manufacturing capabilities in the U.S. For such applications, "sheet" materials (including non-woven materials, fibrillated materials, perforated polymer combinations, and similar materials) may well provide acceptable substitutes for Department of Defense needs. An area of immediate concern is the urgent need for the development of a more readily available tentage material.

5. Investigation of fiber blends.

The Department of Defense must, in the event of mobilization, fulfill its needs by utilization of manufacturing technology in place at the time of mobilization. During recent years, significant changes in fiber blend composition and construction have occurred in the industry as it has sought to satisfy market needs and to meet competition. Such changes can be expected to continue in the years ahead, and the Department of Defense must therefore perform the necessary research and development to characterize the full range of blends and constructions with respect to their ability to satisfy military requirements in uniforms and other applications. With such a bed of data, the Department of Defense could, in time of mobilization, rapidly assess the optimum composition and construction of fabrics available from industry at the time. An example of work envisioned in this area would be the continuation of current efforts to determine the mechanisms of wear in cotton fabrics, as well as cotton blends, and to use this information to predict the wear life in actual field operations.

6. Investigation of material combinations in military clothing and equipment.

The combination of textiles, foams, fibers, and other new materials into structures that will fill military needs would be a logical portion of research and development effort. Because of the peculiar nature of military clothing and equipment, the industry has little incentive to undertake such research and this area has not received adequate support in the Department of Defense in recent years. This effort may include incorporation of sheet materials (see Item 4). The research and development conducted in this area could lead to expanded use of conventional fiber and fabric products by incorporation of such materials in new constructions or in combination with other materials. This could well lead to significant new products for the American consumer and new markets for industry as well.

7. Study of End Item Manufacturing Techniques.

In periods of mobilization, the time to produce critically needed items is often the critical problem in the early stages of conflict. In the construction of clothing articles and other items commonly based on textile technology (such as parachutes and tents), the time to assemble fabrics into the end items is apt to be the critical path in most instances. On an interim and probably even long term basis, totally new concepts in producing such end items should be explored. In the case of garments, stitchless seaming through use of such approaches as improved adhesive systems warrants consideration. A more radical departure is to investigate the use of such items as formable or moldable garments. The successful development of such technology could significantly ease the mobilization problems associated with the time to assemble such items.

8. Evaluation of various approaches to stockpiling.

Recognizing the economic restraints associated with stockpiling, a study should be conducted to evaluate the optimum balance to be achieved between available technology, time to convert, and economics in converting raw materials such as cotton to end products. This would, of necessity, be an on-going effort, in view of the many changes occurring in textile technology today. As an example of this, production of cotton yarns utilizing open end spinning appears to be in a period of significant expansion in the U.S. Such developments in technology, which significantly increase manufacturing rates, would be critical inputs in attempting to reach a decision as to the amount and nature of products to be stockpiled.

9. Investigation of manufacturing technology as it relates to military requirements.

As noted above, new developments such as open end spinning, malimo weaving (sewing), weftamatic knitting, appear to offer the promise of significant changes in production rates in textile technology. Similarly, the development of new construction techniques offer the possibility of producing fabrics at yardage rates from 20-40 times faster than conventional looms. Such new technologies must be available to determine the military applications for which such constructions may be suitable. For mobilization purposes, it is possible that trade-offs can be made between durability and manufacturing rates and such studies would also need to be on a continuing basis.

COTTON AND TEXTILE DEFENSE CAPABILITY COMMITTEE

Chairman

Mr. W. Gordon McCabe, Jr.
Vice President
J. P. Stevens & Company
P. O. Box 1209
Greenville, South Carolina 29602

Members

Mr. Stewart Boswell
Director, Government Relations
American Textile Manufacturers Institute
1150 17th Street, N.W.
Washington, D. C. 20036

Mr. Donald J. May
Director, Economic Information Division
American Textile Manufacturers Institute
1150 17th Street, N.W.
Washington, D. C. 20036

Mr. Alan Polansky
Deputy Director
Bureau of Resources and Trade Assistance
U.S. Department of Commerce
Washington, D. C. 20230

Mr. Charles Raymond
Director, Market Analysis Division
Office of Textiles
U.S. Department of Commerce
Washington, D. C. 20230

Mr. John V. E. Hansen
Director, Clothing, Equipment and
Materials Engineering Laboratory
Department of the Army
U.S. Army Natick Research and
Development Command
Natick, Massachusetts 01760

Mr. Amos D. Jones
Fibers Leader, Commodity Economics Div.
Economic Research Service
U. S. Department of Agriculture
Washington, D. C. 20250

Members (Continued)

Mr. Tony Coelho
Administrative Assistant
Congressman B. F. Sisk
2313 Rayburn, H.O.B.
Washington, D. C. 20215

Mr. Kenneth Frick
Administrator
Agricultural Stabilization and Conservation Service
U.S. Department of Agriculture
Washington, D. C. 20250

Mr. Macon Edwards
Washington Representative
National Cotton Council of America
1030 15th Street, N.W.
Washington, D. C. 20005

Dr. Arlie Bowling
Director, Economics and Market Research
National Cotton Council of America
P. O. Box 12285
Memphis, Tennessee 38112

Dr. Mary Carter
Director, Southern Regional Research Center
Agricultural Research Service
P.O. Box 19687
New Orleans, Louisiana

Mr. Hal Brockman
Vice President
Textile Research and Development
Cotton-Incorporated
4505 Creedmoor Road
Raleigh North Carolina 27609

Mr. William O. Shofner
Deputy Director
Cotton, Rice and Oilseed Division
Agricultural Stabilization & Conservation Service
U.S. Department of Agriculture
Washington D. C. 20250

Mr. Bob Boslett
Vice President
Cotton-Incorporated
1370 Avenue of the Americas
New York, N. Y. 10019

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*

U.S. Army Natick Laboratories
Natick, Mass. 01760

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

NA

3. REPORT TITLE

(6) THE CHANGING CAPABILITY OF THE TEXTILE INDUSTRY TO SUPPORT NATIONAL DEFENSE.

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

(9) Technical Report

5. AUTHOR(S) *(First name, middle initial, last name)*

(10) Stephen J. Kennedy

(12) 14 p.

6. REPORT DATE

(11) June 1973

7a. TOTAL NO. OF PAGES

7b. NO. OF REFS

8a. CONTRACT OR GRANT NO.

(14) NAKADCOM

8b. ORIGINATOR'S REPORT NUMBER(S)

-TR-73-50-CE

b. PROJECT NO.

(16)

c. 1J764713DL40,
1J662713DJ40

d.

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES

Supersedes AD-777 791

12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

This study is directly related to the Army's research and development on new and improved materials for the soldier's clothing and personal life support equipment system that could be produced quickly from a broad base of the textile industry's facilities to meet the logistical support requirements of a possible future mobilization.

Recent trends in the textile industry necessitate a reappraisal of the capability of the textile industry to provide adequate support to the military services in some future national emergency. These trends include: increasing textile imports, the revolutionary changes occurring in textile manufacturing, and the relative shrinkage in size of the industry's broadwoven goods manufacturing capacity in relation to total consumer demand.

This report attempts to formulate some of the problems which can be foreseen at this time, and to indicate some of tne factors that would be involved in assuring an adequate supply of essential military textile materials.

DD FORM 1 NOV 68 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

392 611

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
INDUSTRIAL MOBILIZING	8		6,7			
MILITARY MOBILIZING	8		6,7			
TEXTILE INDUSTRY	8,9		9			
WORSTED FABRICS	9					
DUCK (FABRIC)	9					
COTTON FABRICS	9					
MAN-MADE FIBER FABRICS	9					
ENERGY CRISIS			6,7			
BALANCE OF PAYMENTS			6,7			
OIL IMPORTS			6,7			
PARACHUTES	4					
TENTS	4					
CLOTHING	4					
UNIFORMS	4					